SALMON AND STEELHEAD HABITAT LIMITING FACTORS

IN THE

WASHINGTON COASTAL STREAMS OF WRIA 21

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Several maps have been included with this report for your reference. The maps are appended to the report, either as a separate electronic file (for the electronic copy of this report) or separate printed section (for hard copy). The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. Below is a list of maps that are included in the WRIA 21 map appendix/file:

EXECUTIVE SUMMARY

As directed under Engrossed Substitute House Bill 2496 and Second Engrossed Second Substitute Senate Bill 5595, the habitat conditions of salmonid-producing watersheds within WRIA 21 are reviewed and rated. This includes conditions within the Queets, Quinault, Kalaloch, Raft, Moclips, and Copalis Basins in addition to other smaller streams within WRIA 21. The worst habitat problems are summarized here, but an overview of all the habitat ratings is provided in the Assessment Chapter. The Assessment Chapter also specifies the criteria used to rate habitat conditions. Other components of this report include detailed discussions for each of the habitat conditions, which can be found within the Habitat Limiting Factors Chapter. Also, maps of updated salmon and steelhead trout distribution and riparian conditions are located in a separate electronic file on this disc. This first round report examines salmon and steelhead trout habitat conditions. Later versions will address habitat issues for other salmonids.

One major impediment to assess habitat conditions in this WRIA is the lack of detailed field information. Some data were available in the Quinault, Salmon, and Sams Rivers and the Matheny Creek watershed analyses as well as in an off-channel habitat report for the Clearwater River, but habitat data for other streams were lacking or found only at a coarse scale. New data are expected from the Raft River watershed analysis, as well as from road and culvert assessments conducted by the Washington Department of Natural Resources, but many data needs remain, especially regarding blockages to fish habitat, floodplain conditions, sedimentation, riparian conditions, and water quality measurements.

In the Quinault Basin, little is known about blockages to fish habitat, including lateral blockages to off-channel habitat in the lower Quinault WAU. However, one major concern regarding floodplain conditions is the bank hardening and floodplain road impacts along the Quinault River upstream of Lake Quinault. This area has experienced road washouts and numerous channel changes. It is also an important spawning reach for sockeye salmon, a stock at risk in the Quinault Basin. In addition, sediment problems associated with road fills and undersized culverts are a noteworthy problem in the timber-managed areas of the Quinault Basin. Riparian conditions are mostly “fair” to “good”, with more impacts in the Lake Quinault WAU, and this area also rated “poor” for warm water temperatures. Lake Quinault acts as a buffer to flood events, and flow analysis indicates no trends in peak flows over time. However, the lower Quinault and Cook/Elk Creek WAUs have experienced a considerable loss of hydrologic maturity. The oligotrophic lake is rated “good” for habitat conditions with the exception of nutrient cycling, which is rated “poor” due to declining returns of sockeye salmon.

In the Queets Basin, three watershed analyses provided data for Matheny Creek, the Salmon River, and the Sams River. Extensive habitat surveys for some Clearwater and lower Queets River tributaries were also available. Other than that, recent fine-scale data were generally lacking for the Clearwater sub-basin and for watersheds other than Matheny Creek, the Salmon River, and the Sams River. Access conditions are rated “good” for lands within the Olympic National Park and in the Salmon River. Elsewhere in the Queets Basin, access conditions are a data need. Floodplain impacts such as bank hardening and roads are minimal; however, loss of off-channel habitat is a major concern, especially in the Clearwater, Salmon, and Sams Rivers and in Matheny Creek.

Excess sediment inputs are likely in the timber-managed areas, particularly in the Clearwater sub-basin where road densities are high. Large road fills with small culverts and mid-slope roads in high mass wasting potential areas are the major current concerns, and these problems have been identified throughout the Clearwater, Salmon, and Sams Rivers and in Matheny Creek. Riparian conditions are mostly “good” throughout the Queets Basin, except in the lower Queets and lower Clearwater WAUs, where conditions are mixed. Water temperatures greater than the State AA standard were found in the lower Queets mainstem, lower Sams River, lower Matheny Creek, and the Salmon River, with even warmer temperatures (up to 20.1^{o}C) in the lower Clearwater River. Flow data are insufficient to provide a good analysis, but land cover data indicate that most of the Matheny Creek, the lower Queets WAU, and the entire Clearwater sub-basins rated “poor” for hydrologic maturity.

There are many smaller streams in this WRIA that drain to the Pacific Ocean. The larger ones include Kalaloch and Joe Creeks, and the Raft, Copalis, and Moclips Rivers, in addition to the smaller watersheds, such as Duck, Whale, Camp, Conner, Boone and Wreck Creeks. Data for habitat conditions were generally lacking for all of these basins except for coarse-level data on the WAU level.

Little is known regarding fish habitat access and floodplain conditions in any of these smaller watersheds. Road density is high in Kalaloch Creek and the Raft River WAU, with “fair” road densities in the Moclips River/Joe Creek and Copalis WAUs. Riparian conditions in Kalaloch Creek, the Moclips River and Joe Creek WAU, and the Copalis WAU are mostly “fair” to “good”, while predominately “fair” riparian conditions exist in the Raft River. Warm water temperatures have been documented in the Raft and Moclips Rivers, and low dissolved oxygen levels have led to a 303(d) listing for Joe Creek. Hydrologic maturity is “good” in Kalaloch Creek and the Copalis River WAUs and “poor” in the Raft River and Moclips River/Joe Creek WAUs.

Most estuarine areas within WRIA 21 have no bank hardening, although there has likely been a loss of LWD compared to historic levels. Generally, the estuarine habitat is rated “good”. One exception is the more extensive bank armoring along lower Joe Creek, but quantification is needed to provide a rating. Much of the near shore habitat is part of the Copalis Rock National Wildlife Sanctuary and is rated “good”. One concern is the recent decline in giant kelp, but the cause (natural or human-caused) of the decline is unknown.

INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;

- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon."

- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. In waters shared by salmon, steelhead trout and bull trout we will include all three. Later, we will add bull trout only waters as well as cutthroat trout.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Relative Role of Habitat in Healthy Populations of Natural Spawning Salmon

During the last 10,000 years, Washington State salmon populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of each salmon population, which has resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are units that do not extensively interbreed because returning adults rely on a stream's unique chemical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus maintaining the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It is thought that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1972). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that supports salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, channel physical features, riparian zones, sediment regime, upland conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing oxygen levels. The riparian zone interacts with the stream environment, providing nutrients and a food web base, large woody debris for habitat and flow control (stream features), filtering water prior to stream entry (water quality), sediment control and bank stability, and shade to aid in temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for the different life history stages, which include egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adult salmon return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools for resting with vegetative cover and instream structures such as root wads for shelter from predators. Successful spawning depends on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as two to three weeks. Delays can result in pre-spawning mortality or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage for all species of salmonids. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities that alter stream hydrology. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream, lessening the impact of a potential flood. The natural, healthy river is sinuous and contains numerous large pieces of wood contributed by an intact, mature riparian zone. Both reduce the energy of water moving downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. This not only decreases flood impacts, but also recharges fish habitat later when flows are low. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. Lastly, a natural river system allows floodwaters to freely flow over unaltered banks rather than constraining the energy within the channel, scouring out salmon eggs. A stable egg incubation environment is essential for all salmon, and is a complex function of nearly all habitat components.

Once the young fry leave their gravel nests, certain species such as chum, pink and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bulltrout, and chinook, will search for suitable rearing habitat within the side sloughs, side-channels, spring-fed “seep” areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye salmon populations quickly migrate from their gravel nests to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juveniles (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bulltrout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce the amount and quality of habitat; hence the number of salmon from these species.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bulltrout, and remaining chinook need habitat to sustain their growth and protect them from predators and winter flows. Wetlands, off-channel habitat, undercut banks, rootwads, and pools with overhead cover are important habitat components during this time.

Anadromous stocks of all salmonid species convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends on natural flow patterns, particularly during migration times.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmonid smolts, so adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow, similar water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington State adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as a shallow and less frequent pools due to elevated sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

The pink salmon fry emerge from their gravel nests in February to April, and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington are only in the rivers in odd years. The exception is the Snohomish Basin, which supports two pink salmon stocks. One stock spawns in odd years, and the other stock spawns in even years.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis Basin, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the upper reaches where higher gradient habitat exists. Incubation continues throughout the autumn and winter and generally requires more time for the eggs to develop into fry because of the colder water temperatures in the upper reaches. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have a component of the juvenile population that begin to leave the rivers to the estuary over the next several months, lasting until August. Within the Puget Sound stocks, it is not uncommon for other juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook stocks in the Columbia Basin exhibit more distinct juvenile life history characteristics. Generally, these stocks remain in the river for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the mainstem Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September or October. Fall chinook stocks range in spawn timing from late September through December. All Washington State summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and downstream migration to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side channels for up to two months. Then, some gradually move into the faster areas to rear, and others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia River upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet (Chuck Baranski, WDFW, personal communication). Adults typically enter freshwater from September to early December, but have been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning often occurs in tributaries and sedimentation in these tributaries can be a problem, with fine sediments suffocating eggs and excess coarse sediment decreasing channel stability. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased water temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, bushes, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories, but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in their stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, and hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette and Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although a few types of fry migrate to the sea. Lake rearing ranges from one to three years with most juveniles rearing two years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, sedimentation, and weed control.

Steelhead have one of the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al. 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. Coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea (anadromy) or remain in freshwater as rainbow trout. In Washington, those that are anadromous usually spend one to three years in freshwater, with the greatest proportion spending two years (Busby et al 1996). Because of this and their year-round presence in steelhead-bearing streams, steelhead greatly depend on the quality and quantity of freshwater habitat.

Bulltrout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they rear during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bulltrout are generally recognized as a sensitive species by natural resource agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last

10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time and competing for food items. These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon production contributes to habitat and to other species.

Introduction to Habitat Impacts

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and wood. These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors. Provided first though, is a general description of the current and historic habitat including salmon populations.

SALMONID DISTRIBUTION AND WATERSHED DESCRIPTION AND CONDITION FOR STREAMS IN WRIA 21

Introduction

This report describes salmonid distribution and habitat conditions in streams located within WRIA 21 (Map 1). This includes Kalaloch Creek to the north and Conner Creek to the south. The largest basins within the WRIA are the Queets and Quinault Basins.

Salmonid distribution in WRIA 21 is shown in Maps 2a-2f. Data sources include the Quinault Watershed Analysis (Quinault Indian Nation and U.S. Forest Service 1999), the Salmon River Watershed Analysis (Quinault Indian Nation 2000), Matheny Creek, Sams River, and Boulder-Cook Creek Watershed Analyses (U.S. Forest Service 1995, 1996, 1997), C. Holt and R. Potter, Quinault Indian Nation, unpublished data, J. Meyer, Olympic National Park, unpublished data, and StreamNet 2000. The level of detail varies between streams and between species. Not all reaches have been extensively surveyed. In some watersheds, fish distribution has been verified by electrofishing, while others show only areas of known adult spawning.

Coastal cutthroat presence or distribution is presented in these sections, where such information is documented (WDFW 2000a). In other streams, the presence of resident or anadromous coastal cutthroat could be assumed given their wide distribution in many coastal streams. Research in the Clearwater sub-basin (Edie 1975) identifies the upper zone of coastal cutthroat habitat as tributary headwaters with gradients of 2 to 6% and widths between 1 and 10 feet including lowland lakes and beaver ponds. Resident cutthroat territory may be inaccessible to searun cutthroat.

The Quinault Basin Habitat Description and Salmon Distribution

Quinault Basin Habitat Description

The headwaters of the Quinault River originate in the Olympic Mountains within the Mount Lawson and Enchanted Valley watersheds. The Quinault River then flows into Lake Quinault, a 3,729-acre natural lake. Downstream of the lake, the Quinault River flows for 33 miles to the Pacific Ocean. The total watershed area is 293,880 acres.

The lowlands in the western part of this watershed contain several hundred feet of glacial deposits with lake and swamp deposits formed in interglacial periods. The low terrain downstream of Lake Quinault contrasts with the steep slopes and high relief of the areas around Lake Quinault and in the headwaters.

Yearly precipitation is high, averaging 146 inches at Lake Quinault. In the upper watershed, much of this precipitation falls as snow, while most falls as rain downstream of the lake. The steep topography and shallow soils of the upper watershed generate both a quick hydrologic response and a high susceptibility to mass wasting events. In contrast, the relatively flat terrain and outwash silts and clays downstream of the lake result in a low susceptibility to mass wasting events and a slower hydrologic response. Because Lake Quinault traps all sediment coarser than silt, the river downstream of the lake is a product of the interactions between the floodplain and the surrounding coastal piedmont.

Most of the watershed lies within the Sitka spruce and silver fir vegetation zones. Mountain hemlock and sub-alpine and alpine meadows border the mainstem and North Fork Quinault Rivers. The most common historic disturbances within the watershed have been wildfire and windstorms. Windstorms typically come from the southwest, heavily affecting the coastal plain and the windward mountain slopes. The most common recent disturbance within the watershed has been timber harvest, which has included clearcutting, broadcast burning, and planting of Douglas fir.

<u>Salmonid Distribution in the Quinault Basin</u>

The Quinault River system contains naturally-reproducing anadromous stocks of spring/summer chinook, fall chinook, coho, chum, pink, and sockeye salmon, winter and summer steelhead trout, anadromous and resident cutthroat trout, and bull trout/Dolly Varden (Maps 2a-2i). In addition, bull trout are present as a resident life form, as are resident rainbow trout. Introduced species include the common carp in Lake Quinault and brook trout upstream of Lake Quinault.

The Quinault River provides commercial fisheries for sockeye, fall chinook, coho, and chum salmon and winter steelhead trout. Commercial catches of spring/summer chinook salmon and summer steelhead trout are incidental to other spring and summer fisheries. In addition, recreational fisheries exist for fall chinook, coho, and chum salmon, and winter and summer steelhead, cutthroat and brook trout (Mobbs 1999a; Phinney et al. 1975).

Mount Lawson WAU

The Mount Lawson WAU includes the North Fork Quinault River and tributaries and contains the uppermost areas of anadromous salmonid use in the Quinault Basin. Chinook, coho, and sockeye salmon and steelhead trout are known to use the North Fork Quinault River up to RM 8 (Maps 2a-2e). It is possible that chum salmon may also be present up to this point. Coho salmon are known to be present in Wild Rose, Rustler and Squaw Creeks, with fall chinook salmon in Rustler Creek (Maps 2b and 2c). Bull trout/Dolly Varden have been found in the North Fork and in Rustler Creek (Map 2h). Cutthroat trout are present, but with an unknown distribution. In addition to native salmonid species, brook trout exist in this watershed, as a result of past plantings in alpine lakes by the Olympic National Park and Washington Dept. of Wildlife (Mobbs 1999a; WDFW 1998, 2000).

Enchanted Valley WAU

The Enchanted Valley WAU includes the mainstem Quinault River and tributaries from the headwaters to the confluence with the North Fork Quinault. The mainstem contains the same anadromous species as the North Fork Quinault River with anadromous fish distribution extending to RM 53.0. Coho salmon are also found in several unnamed tributaries and Graves Creek (Map 2c). Bull trout/Dolly Varden have been found in the East Fork Quinault, both above and below the anadromous barrier, up to RM 65.5 (WDFW 1998). Cutthroat trout are present, but with an unknown distribution. In the past, brook trout have been planted in this watershed (Mobbs 1999a; WDFW 1998, 2000).

Lake Quinault WAU

All of the species found upstream of this WAU are found here as well. Coho, chinook, sockeye, and chum salmon and steelhead trout are found in the Quinault River. Coho salmon are found in Higley, Slide, Finley, Irely, Bunch, Cannings, and Howe Creeks and in two unnamed tributaries (Map 2c). Coho, chinook, and sockeye salmon and steelhead trout are found in Willaby, Falls, Gatton, Zeigler, Kestner, Inner Creek Slough, Alder, Big, Fox, and Fletcher Creeks. Chum salmon are found in Fletcher, Alder, Big, Inner Creek Slough and Zeigler Creeks (Map 2f). Coho and sockeye salmon are found in Haas Creek and in two unnamed streams. Steelhead trout spawn in Canoe, Irely and Bunch Creeks (Map 2e). Cutthroat trout are present throughout the WAU, but the upper limits of their distribution have not been defined. Bull trout/Dolly Varden are present in the region with an unknown distribution. Brook trout and common carp were not historically present in the WAU, but common carp can be found in Lake Quinault and brook trout exist upstream of Lake Quinault. A fishway was installed in Falls Creek, near the mouth to facilitate fish passage to an additional 1.4 miles of habitat.

The Cook Creek Watershed

Coho, fall chinook, and chum salmon and summer and winter steelhead trout are known to be present in Cook Creek. Coho are found in Chow Chow, Elk, and Red Creeks (tributaries to Cook Creek) (Map 2c). In addition, fall chinook salmon, chum salmon, and steelhead trout are found in Elk Creek (Maps 2b, 2e, and 2f). Sea-run cutthroat were historically present, although their current distribution is not known. Dolly Varden have also been documented in Cook Creek, but it is unknown whether this is a resident or anadromous population. This watershed contains resident cutthroat trout, although the distribution is not known. Bull trout use and distribution are also unknown (Mobbs 1999a). Olympic mud minnow are present in the Cook Creek system (Harris 1974).

Lower Quinault River Sub-Basin

The lower Quinault River downstream of Lake Quinault provides habitat for anadromous populations of coho, chinook, chum, and pink salmon and winter steelhead and sea-run cutthroat (Maps 2a-2g). Coho salmon are also found in Canyon, Railroad, No Name, Mounts, O'Took, Joe, Boulder, Ten O'clock, Camp Prairie, Dry Boulder, McCalla, and Hathaway Creeks, while chinook and steelhead are found in Boulder and Ten O'clock Creeks. Chinook salmon are also found in Prairie and McCall Creeks, and chum salmon use Boulder and Ten O'clock Creeks. Resident cutthroat trout and Dolly Varden are present in the mainstem and tributaries, although the extent of their distribution is unknown. Bull trout presence and distribution is also not known. Olympic mudminnow are present in off-channel habitats within the Quinault River mainstem (Harris 1974; Mobbs 1999a).

Historic Land Use in the Quinault Basin

Prior to the Cosmopolis and Quinault River treaties (circa 1855), the Quinault watershed was claimed by the Quinault Tribe as their ancestral homeland and was used for subsistence fishing, hunting, and use of plants for food, medicine and tools. Formal land ownership began with the Quinault River Treaty in 1855.

Euroamerican settlers arrived in the late 1880s, resulting in subsistence farming and grazing in valley bottomlands, primarily in the Quinault Lake and Cook Creek watersheds. Timber harvest began in earnest in 1916, when cedar was salvaged from the 300-acre "Neilton burn". Railroad construction provided access for timber harvest in the Quinault River and Cook Creek watersheds between 1917 and 1940. Extensive road construction and subsequent timber harvesting occurred between 1950 and 1980. While the level of old growth harvesting has declined in recent years, second growth forest management and specialty forest products continue to be economically important. In 1978, the Quinault Nation embarked on a program to reacquire lands on the reservation to return them to tribal ownership and coordinated management. Most or all lands within the Quinault Indian Reservation and U.S. Forest Service ownership have been harvested at least once. This includes the lowlands, Quinault Valley, and areas on Higley and Quinault Ridges.

Much of the Cook Creek watershed and the lands north and east of Lake Quinault were declared part of the Olympic Forest Reserve in 1897 (James 1999). The U.S. Forest Service managed the area until the establishment of Olympic National Park in 1938. The Forest Service designated the Quinault Recreation Area in 1922 and the Quinault Research Natural Area in 1932. The Colonel Bob Wilderness was included in the federal wilderness areas in 1984 (James 1999).

Current Land Use in the Quinault Basin

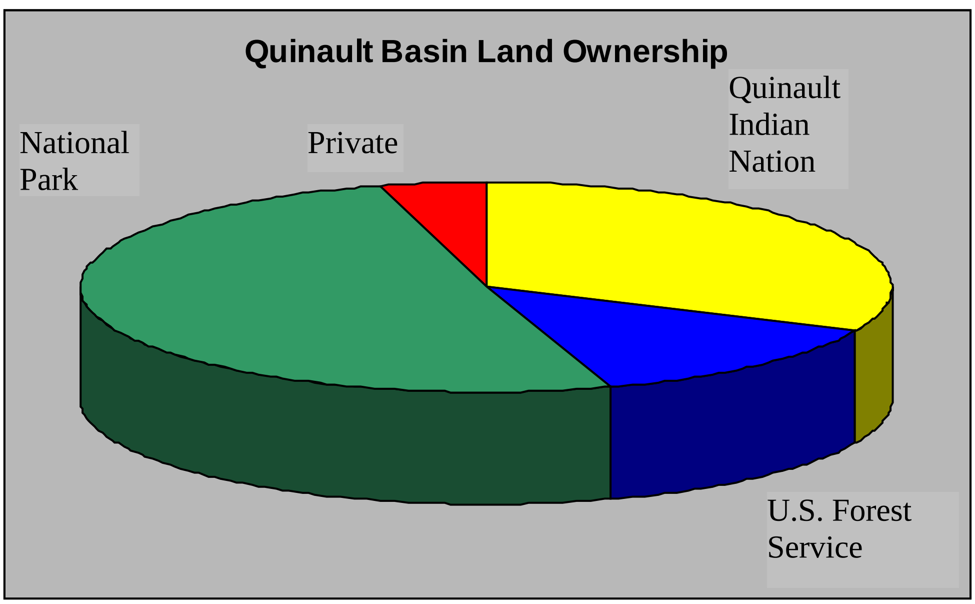
Current land uses within the basin include timber harvest, fishing and tourism, and the major landowner is the Olympic National Park (ONP), which includes all of the Mount Lawson and Enchanted Valley watersheds (Figure 1). The Quinault Indian Nation owns 32% of the basin, comprising most of the area downstream of Lake Quinault (Quinault Indian Nation and U.S. Forest Service 1999). The U.S. Forest Service manages 13% of the watershed, including the eastern part of the Cook Creek watershed and the southwest half of the Lake Quinault watershed between Quinault Ridge and the upper Quinault River. Private landholdings comprise only 4% of the lands in the basin, and Rayonier Timberlands Company is the largest private landholder, managing 14,030 acres in the Cook Creek area (Quinault Indian Nation and U.S. Forest Service 1999). Washington

State lands managed by the Department of Natural Resources (DNR) encompass 0.1% of the drainage area. Present-day settlements are small and include the village of Taholah and the Amanda Park and Neilton areas. Currently, two hatcheries operate within the watershed. The Quinault National Fish Hatchery is located near Cook Creek, and the Quinault pen rearing facility is located in Lake Quinault.

Lands within the Olympic National Park will continue to be managed as wilderness, and this includes the maintenance of access roads for visitors (ONP 2000). Lands in the Olympic National Forest will continue to be managed under the Northwest Forest Plan (1994), which amends the Olympic Land and Resource Management Plan (1990) (Olympic National Forest 2000). This plan includes establishment of key watersheds and riparian reserved to sustain water quality, fisheries and aquatic habitat, and establishment of late-successional reserves to maintain old-growth forests. The Quinault Research Natural Area is preserved in a natural state for research and education, and the Colonel Bob Wilderness Area is managed as wilderness (Olympic National Forest 2000).

The Quinault Tribe is completing a forest plan for all timberlands on the Quinault Indian Reservation. Goals include timber harvesting using sustained yield management for employment and economic return; sustaining or enhancing fish habitat and water quality; sustaining or enhancing wildlife habitat; and enhancing traditional and cultural values (Quinault DNR 2000).

Figure 1. Land ownership in the Quinault Basin (Quinault Indian Nation and U.S. Forest Service 1999).



The Queets Basin Habitat Description and Salmon Distribution

Queets Basin Habitat Description

The Queets River originates in the Olympic Mountains with steep headwaters and upper tributaries. Tributaries drain precipitous ridges, although long areas of moderate-gradient tributaries and low-gradient mainstem reaches are also present. Major tributaries of the Queets River include the Clearwater, Salmon and Sams Rivers, and Matheny and Tshletshy Creeks. Major tributaries of the Clearwater include the Solleks and Snahapish Rivers, and Christmas and Stequaleho Creeks.

The watershed has a temperate maritime climate, with average annual precipitation of 120 to 200 inches. The wettest season is between November and April. Prevailing winds are from the southwest, and winter storms delivering over ten inches of precipitation in a single event are not uncommon. Elevations below 1500 feet are generally rainfall dominated, while mixed rain and snow are common between 1500 and 3000 feet, and precipitation in elevations above 3000 feet is dominated by snow (Washington DNR 1997).

The Sitka spruce zone extends along the coast and inland up the Queets River valley, while the western hemlock zone dominates from sea level to approximately 2000 feet in elevation. The Pacific silver fir zone exists from 2000 to 4000 feet in elevation and extends upwards to the sub-alpine forest in the Olympic Mountains. Sub-alpine fir and hemlock forests are found from elevations of approximately 4,000 feet to the timberline (Washington DNR 1997).

Salmonid Distribution in the Queets Basin

Salmonids are widely distributed throughout the Queets Basin, with naturally reproducing anadromous stocks of spring/summer chinook, fall chinook, coho, sockeye, chum, and pink salmon, and winter and summer steelhead, anadromous and resident cutthroat, resident rainbow trout and bull trout/Dolly Varden (Phinney et al. 1975; Quinault Indian Nation, unpublished data 2001; U.S. Forest Service 1995, 1997; Quinault Indian Nation 2000). Chinook salmon and steelhead trout spawn in the mainstem Queets, Clearwater, Sams, and Salmon Rivers, Matheny Creek, and several tributaries, such as Miller Creek, Christmas Creek, the Snahapish River, and the Solleks River (Maps 2a, 2b, 2e, and 2j). Chum salmon spawn in the lower reaches of the Queets, Clearwater, and Salmon Rivers and in Matheny Creek (Map 2f). Coho salmon spawn in the mainstem Queets and Clearwater Rivers, as well as in all accessible tributaries (Map 2c). Bull trout/Dolly Varden are present in the mainstem Queets and the Salmon Rivers, but the distribution in many other tributaries, such as the Clearwater River, the Sams River, and Matheny Creek, is unknown (Phinney et al. 1975; WDFW 1998, 2000a).

Hatchery production in the Salmon River includes fall chinook salmon, winter steelhead trout, an early coho salmon stock for release in the Salmon River, and a later native coho stock for release elsewhere in the Queets and Clearwater systems (Phinney et al. 1975; D.

Boyer, Quinault Indian Nation, unpublished data 1999). The Queets River provides commercial fisheries for fall chinook, coho, and chum salmon and winter steelhead trout. In addition, recreational fisheries exist for fall chinook, coho, and chum salmon, as well as for winter and summer steelhead, and cutthroat trout.

<u>Historic Land Use in the Queets Basin</u>

Native Americans have inhabited the Queets Basin for thousands of years. The Queets River was the main watercourse for resource gathering, although many tributary streams were also used for specific resource harvesting, such as salmon, eels, flora, and fauna. The Salmon River also functioned as the main travel route between the interior of the Queets River and points south (Lake Quinault, Taholah and Oyhut). The Queets Tribe is an affiliate member of the Quinault Indian Nation. Subsequent to the Treaty of 1855 (the Quinault River Treaty), the Quinault Indian Reservation was established in 1861. In 1983, the reservation boundaries were enlarged to include the lower eight miles of the Queets River and the estuary (James 2000).

In 1889, European-Americans began to homestead the Queets River valley for subsistence farming. These homesteads were also in the watersheds of tributary streams, including the Clearwater, the Salmon, and the Sams Rivers, and Matheny Creek.

In 1897, portions of the Olympic Peninsula were placed in the Olympic Forest Reserve, which included parts of the Queets headwaters. These boundaries were later both reduced and added to, and renamed the Olympic National Monument. In 1938, the Olympic National Park was created, and additional land within the Queets Basin was added to the park. Although acquisition of homesteaded properties in what is now called the Queets Corridor began during the 1930s, many farms were condemned in 1940 to create the corridor in 1953. Beginning in the 1940s, lands on the outside edge of the corridor were sold for timber harvest (Felt 1985; McLeod 1984; James 2000).

Timber harvest began during the 1940s and 1950s in the Sams, Matheny, Salmon, and Clearwater sub-basins, with the peak of timber harvest taking place between 1960 and the mid-1980s. Generally, harvest activities started on the flatter valley floor areas and moved upstream into steeper terrain during the later portions of these decades. During this time period, increased road densities, stream crossings, and road construction on steep hillslopes amplified sediment inputs to many stream channels (U.S. Forest Service 1995, 1997; Quinault Indian Nation 2000; Reid 1981).

Commercial timber harvest on U.S. Forest Service lands has been virtually non-existent since 1994 (Lasorsa 2000). Commercial harvest on private and DNR lands primarily in the Clearwater sub-basin has continued although at a lower rate than that seen during the 1980s (WA DNR 1997).

Current Land Use in the Queets Basin

Current land uses within the watershed include timber harvest, agriculture, fishing, recreation, and tourism. Present-day settlements include the small communities of Queets and Clearwater.

Olympic National Park Lands

The Olympic National Park ownership includes 20.8 miles of the Queets River and 34 tributary streams (Phinney et al. 1975). The Queets Basin upstream of the Sams River confluence (RM 23.5), including the Tshletshy Creek watershed, is part of Olympic National Park, with the lower five miles of the Sams River as the boundary between the Park and Olympic National Forest. The Queets Corridor is also under Park ownership and includes the mainstem Queets and its valley between RM 8 and RM 23.5 and the lower reaches of many tributary streams, including the Sams River (6,044 acres), Matheny Creek (387 acres), and the Salmon River (408 acres). Olympic National Park lands along the coastal strip include the lower mile of Kalaloch Creek. It is expected that timber harvest on these lands will be virtually non-existent.

U.S. Forest Service Lands

The U.S. Forest Service owns 84% of the Matheny Creek watershed, 73% of the Sams River watershed, and 30% of the Salmon River watershed, as well as some acreage north of the Queets River near the town of Queets at RM 23. All of these watersheds have established Riparian Reserves, while lands outside of the riparian reserves are managed as Late Successional Reserves or Adaptive Management areas (Lasorsa 2000; U.S. Forest Service 1995, 1997).

Washington Department of Natural Resources Lands

Washington DNR lands comprise 79% of the Clearwater sub-basin (T. Hartrich, Quinault Indian Nation, unpublished data 2000). All Washington DNR lands in the Queets and Clearwater systems are managed as part of the Olympic Experimental Forest, which has a management objective of melding habitat conservation and timber production across the landscape, rather than separating each into designated areas. This management plan includes monitoring and research (Washington DNR 1997). The riparian conservation strategy calls for interior riparian buffer zones and exterior riparian wind buffer zones (Washington DNR 1997).

Privately Owned Lands

In the Clearwater sub-basin, privately owned lands comprise approximately 20% of the total acreage (T. Hartrich, Quinault Indian Nation, unpublished data 2000). Most of the privately owned lands are in the lower Clearwater sub-basin.

Quinault Indian Nation Lands

Lands in the Quinault Indian Reservation include the lower eight miles of the Queets River and the estuary and 54% of the Salmon River drainage (South Fork, Middle Fork, and lower mainstem Salmon Rivers) (Quinault Indian Nation 2000). These lands are managed under the Quinault Forest Plan for sustainable timber harvest, maintenance or enhancement of fish and wildlife habitat, consolidation of tribal lands, and enhancement of traditional and cultural values.

The Kalaloch Basin Habitat Description and Salmon Distribution

<u>Current & Historic Land Use in the Kalaloch Basin</u>

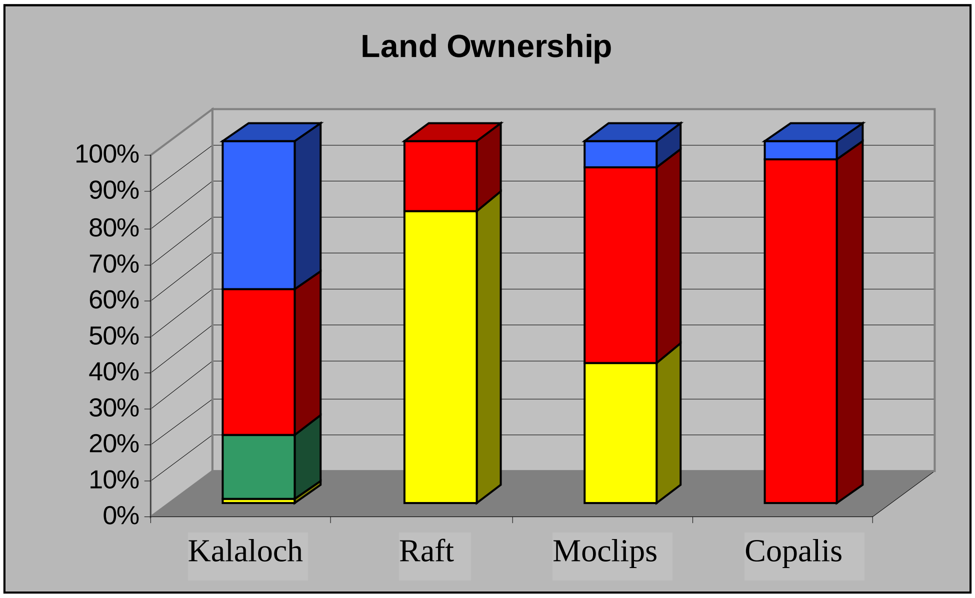
The Kalaloch Basin is 13, 649 acres in size and includes Kalaloch Creek and four small, un-named, independent tributaries that drain to the Pacific Ocean to the south of Kalaloch Creek. Most of the drainage consists of either privately owned land (40%) or Washington DNR lands (41%) (T. Hartrich, Quinault Indian Nation, unpublished data). The Olympic National Park owns 18% of the basin, including the coastal strip and approximately one mile of lower Kalaloch Creek (Figure 2). The Quinault Indian Nation lands include 1% of the drainage (T. Hartrich, Quinault Indian Nation, unpublished data).

Land use outside of the Olympic National Park is predominantly forestry. Past land uses included homesteading on the coastal strip (which was added to the Olympic National Park in 1940) (Felt 1985) and forestry. The timber harvest history for private lands in this basin is not known, and the specific harvest history for Washington DNR lands is not known either, but can be assumed to be similar to the adjacent Clearwater and Hoh Basin DNR lands, with high levels of harvest starting in the 1940s and continuing through the mid-1980s (Felt 1985). Future land use is expected to be recreation on the Olympic National Park lands and timber management in the DNR Olympic Experimental Forest and on privately owned timberlands.

<u>Salmonid Distribution in the Kalaloch Basin</u>

Coho salmon, winter steelhead, bull trout/Dolly Varden and coastal cutthroat trout are present or were historically present in streams within the Kalaloch Creek sub-basin (StreamNet 2000; WDFW and WWTIT 1994; WDFW 1998, 2000; Johnson et al. 1999). A small run of chum salmon was also historically present in Kalaloch Creek (Phinney et al. 1975). The StreamNet database lists coho salmon and winter steelhead trout in Kalaloch Creek between RM 0.0 and RM 3.9 and in the West Fork Kalaloch Creek between RM 0.0 and RM 2.4 (Maps 2c and 2e) (StreamNet 2000).

Figure 2. Land ownership in the Kalaloch, Raft, Moclips, and Copalis Basins.



The Raft River Basin Habitat Description and Salmon Distribution

The Raft River Basin totals 71,824 acres in size, and includes the Raft River, North Fork Raft River, Red Creek and independent tributaries, such as Duck, Camp and Whale Creeks. Most (81%) of the basin is owned by Quinault Indian Nation or tribal members, and privately owned lands comprise the remainder (19%) (Figure 2) (T. Hartrich, Quinault Indian Nation, unpublished data 2000). Current and expected future land use includes forestry and tribal cultural uses.

Declines of the Raft River salmon and steelhead populations became evident in the 1950s, and were attributed to habitat damage from timber harvest practices. The Quinault Tribe closed the Raft River to gillnet fishing in 1962 due to declining population levels (Lestelle and Blum 1988). In 1967, 5,800 acres within the Raft River drainage burned, fueled by logging debris (Workman 1997). Phinney et al. (1975) noted, "extensive areas of clearcut logging" and "streams choked with logging debris" in the Raft Basin, continuing "...Logging and associated road construction have been conducted with no regard to salmon habitat."

Coho salmon, chum salmon, and steelhead trout were known to use the Raft River, and coho were noted in Whale and Camp Creeks (Maps 2c and 2e) (Phinney et al 1975; Lestelle and Blum 1989). Historic use of streams in the Raft River Basin by anadromous and resident coastal cutthroat trout and bull trout/Dolly Varden is not documented, but the USFWS currently assumes that bull trout were present in the Raft River Basin (Mark Mobbs, Quinault Indian Nation, personal communication). There is some anecdotal evidence that Raft River population levels of salmon and steelhead may be recovering. A watershed analysis is planned by the Quinault Indian Nation in 2001 to 2002 to investigate this question and to identify restoration opportunities.

The Moclips Basin Habitat Description and Salmon Distribution

The Moclips River Basin is 53,528 acres in size, and includes the Moclips River, North Fork Moclips River, Wreck Creek, and Joe Creek. The majority (54%) of the sub-basin is privately owned, while tribally owned lands comprise 39% of the basin (T. Hartrich, Quinault Indian Nation, unpublished data 2000). State-owned lands include 7% of the drainage (Figure 2). Land use is predominantly forestry, with the coastal strip containing the communities of Moclips and Pacific Beach. Future land use is expected to include timber production, recreation, and residential areas along the coastal strip.

Timber harvest began fairly early in the century, as railroad and road logging efforts moved north from Hoquiam and Aberdeen. By the 1950s, most of the reservation south of the Quinault River had been logged (Capoeman 1990; Workman 1997; Van Syckle 1981). A dam for a log pond was present on the Moclips River (date of construction unknown), apparently at RM 1.3 within the town of Moclips. A fish ladder was installed in 1940, and the dam was removed some time prior to 1974 (Wendler and Deschamps 1955; Phinney et al. 1975; Fairbairn 1982).

Coho salmon and winter steelhead, bull trout/Dolly Varden, and coastal cutthroat trout use streams within this basin, and historically, a small run of chum salmon spawned in the Moclips River (Phinney et al. 1975). The StreamNet database lists coho salmon as using the Moclips River mainstem between RM 0.0 and RM 4.8 and winter steelhead and coho between RM 0.0 and RM 7.0 (Maps 2c and 2e). Winter steelhead trout spawn in the North Fork Moclips between RM 0.0 and RM 2.0, and coho salmon between RM 0.0 and RM 11.2 (StreamNet 2000). In addition, the database lists coho salmon and winter steelhead trout as using the Wreck Creek mainstem from RM 0.0 to RM 0.5. Joe and Beaver Creeks provide habitat for coho and chum salmon, with Joe Creek coho spawning between RM 0.0 and RM 3.6, and the extent of chum salmon use in these streams unknown (Phinney et al. 1975; StreamNet 2000).

Declines of Moclips River salmon and steelhead populations became evident in the 1940s, and were attributed to habitat damage from timber harvest practices. The Quinault Tribe closed the Moclips River to gillnet fishing in 1962 due to decreasing population levels (Lestelle and Blum 1988), but has since re-opened to commercial fishing (Mark Mobbs, Quinault Indian Nation, personal communication).

The Copalis Basin Habitat Description and Salmon Distribution

The Copalis River drainage is 36,818 acres in size, and includes the Copalis River and Connor Creek. This basin is 95% privately owned, with 5% of state owned lands (Figure 2) (T. Hartrich, Quinault Indian Nation, unpublished data 2000). Land use is predominantly forestry, with recreation and residential areas along the coastal strip, containing the communities of Copalis Beach and Ocean City. Future land use is expected to continue to be timber production, recreation and residential.

Like the Moclips Basin, railroad logging occurred early in the century in the Copalis watershed (Van Syckle 1981). At least one dam for a log pond existed in the Copalis River, although it was removed in 1920 (Wendler and Deschamps 1955).

Coho salmon, winter steelhead, bull trout/Dolly Varden, and cutthroat trout (resident and anadromous) are listed as currently or historically present in the Copalis River (Phinney et al. 1975; WDFW and WWTIT 1993; StreamNet 2000; WDFW 1998, 2000; Johnson et al. 1999). Coho salmon and winter steelhead trout spawn in the Copalis River mainstem from RM 0.0 to RM 15.9 (Maps 2c and 2e) (StreamNet 2000). Boone Creek provides habitat for coho salmon, while coho and chum salmon utilize Connor Creek. Stock status and exact fish distribution are not known for streams in this basin.

SALMONID STOCK STATUS IN WRIA 21

Salmonid Status in the Quinault Basin

In 1992, Quinault fall chinook, Cook Creek fall chinook, Quinault chum, Cook Creek coho, and Quinault sockeye salmon, and Quinault and Upper Quinault winter steelhead trout were all classified as "healthy" (Table 1) (WDFW and WWTIT 1994). Quinault spring/summer chinook salmon were classified as "depressed", based upon a short-term severe decline in adult escapement levels. Four stocks (Quinault fall coho salmon, summer steelhead trout, coastal cutthroat, and bull trout/Dolly Varden) were listed as an "unknown" status in the Quinault River (WDFW 1998, 2000a; WDFW and WWTIT 1994).

Recent returning populations of fall chinook, coho, chum, and sockeye salmon and winter steelhead trout have been fairly stable. In an analysis of winter steelhead trout run size and escapement estimates from 1977 to 1995, a downward trend in lower river escapement was noted, and no trend in upper river escapements was found (Mobbs 1999a). While coho salmon returns between 1980 and 1996 appear to have been fairly stable, returns of coho are much reduced compared to historic levels (Lestelle and Blum 1989).

An analysis of historic data in 1981 found a reduction in sockeye salmon returns between 1908 and 1975, and recent returns are also much reduced compared to historical levels (Quinault Indian Nation 1981). From 1972 to 1995, no trends in run size or escapement were found (Mobbs 1999a). A small sockeye return in 1998 to 1999 has caused concerns. This situation is under study (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication 2000).

Table 1. Stock Status of Salmon, Trout and Char in the Quinault Basin.

Stock	Origin	Production	Status	Comments
Spring/summer chinook salmon	Native	Wild	Depressed	Based on severe short-term decline in escapement
Fall chinook salmon	Native	Wild	Healthy	
Cook Creek fall chinook salmon	Mixed	Composite	Healthy	
Chum salmon	Mixed	Composite	Healthy	
Coho salmon	Mixed	Composite	Unknown	
Cook Creek coho salmon	Mixed	Composite	Healthy	
Sockeye salmon	Native	Wild	Healthy	
Summer steelhead trout	Native	Wild	Unknown	Historically small numbers
Quinault/Lake Quinault Winter steelhead trout	Mixed	Wild	Healthy	
Upper Quinault winter steelhead trout	Native	Wild	Healthy	Isolated spawning population in upper river
Coastal cutthroat	Native	Wild	Unknown	Concern expressed for all coastal stocks (Nehlsen et al. 1991).
Bull trout/Dolly Varden	Native	Wild	Unknown	
Pink salmon				Historically small numbers

Salmonid Stock Status in the Queets Basin

Most of the salmonid stocks within the Queets Basin are currently believed to be healthy. Spring/summer chinook are "depressed", while all others are either "healthy" or "unknown". See Table 2 for a summary of stock status in the Queets Basin.

Table 2. Queets Basin Salmon, Trout and Char Stock Status.

Stock	Origin	Production	Status	Comments
Spring/summer chinook	Native	Wild	Depressed	Based on short-term severe decline in escapement
Fall Chinook	Native	Wild	Healthy	Indicator stock for North Coast fishery
Coho	Mixed	Composite	Healthy	
Winter & summer steelhead	Native	Mostly natural	Healthy	Some hatchery production
Chum	Unknown	Unknown	Unknown	
Pink	Unknown	Unknown	Unknown	
Sockeye	Native	Wild	Healthy	Low numbers
Coastal cutthroat	Native	Wild	Unknown	Concern expressed for all coastal stocks (Nehlsen et al. 1991).
Bull trout/Dolly Varden	Native	Wild	Healthy	

Sources: WDFW and WWTIT 1994; WDFW 1998, 2000a; Nehlsen et al. 1991.

Salmonid Stock Status in the Kalaloch Creek Basin

Coho salmon, winter steelhead trout, bull trout/Dolly Varden and coastal cutthroat trout are present or were historically present in streams within the Kalaloch Creek Basin. The status of these stocks is "unknown" (Table 3). Also, chum salmon were historically present in Kalaloch Creek.

Table 3. Salmonid Stock Status in the Kalaloch Creek Sub-Basin.

Stock	Origin	Production	Status	Comments
Coho	Native	Wild	Unknown	
Winter steelhead	Native	Wild	Unknown	Historically small numbers
Coastal cutthroat				Presence likely
Bull Trout/Dolly Varden				Assessed as part of Queets Stock
Chum				Historically present

(StreamNet 2000; Phinney et al. 1975; WDFW and WWTIT 1993; WDFW 1998, 2000a; Johnson et al. 1999).

Salmonid Stock Status in the Raft River Basin

Coho salmon, chum salmon, and winter steelhead trout were known to use the Raft River, and coho were noted in Whale and Camp Creeks (Phinney et al 1975; Lestelle and Blum 1989). In 1992, coho salmon and winter steelhead trout were the only two salmon and steelhead stocks noted within the Raft River (WDFW and WWTIT 1994). Both have an "unknown" stock status. No information regarding the status of coho salmon and winter steelhead trout in Whale and Camp Creeks was found. Historic use of streams in the Raft River Basin by anadromous and resident coastal cutthroat trout and bull trout/Dolly Varden is also unknown.

Salmonid Stock Status in the Moclips River Basin

Coho, chum, winter steelhead, bull trout/Dolly Varden, and coastal cutthroat trout use streams within this basin. Winter steelhead trout are listed as “healthy”, but the status for the remaining stocks is “unknown” (WDFW and WWTIT 1994).

Table 4. Salmonid Stock Status in the Moclips River Basin.

Stock	Origin	Production	Status	Comments
Coho	Mixed	Composite	Unknown	
Winter steelhead	Native	Wild	Healthy	
Bull Trout/Dolly Varden	Native	Wild	Unknown	
Chum				Historically present
Cutthroat trout	Native	Wild	Unknown	

(StreamNet 2000; Phinney et al. 1975; WDFW and WWTIT 1993; WDFW 1998, 2000a; Johnson et al. 1999).

Salmonid Stock Status in the Copalis River Basin

Coho, winter steelhead, bull trout/Dolly Varden, and cutthroat trout (resident and anadromous) are listed as currently or historically present in the Copalis River (Table 5). Boone Creek provides habitat for coho salmon, while coho and chum salmon utilize Connor Creek. Stock status and exact fish distribution are not known for streams in this basin.

Table 5. Salmonid Stock Status in the Copalis Basin.

Stock	Origin	Production	Status
Coho	Mixed	Composite	Unknown
Winter steelhead	Native	Wild	Unknown
Bull Trout/Dolly Varden	Native	Wild	Unknown
Cutthroat trout	Native	Wild	Unknown

(StreamNet 2000; Phinney et al. 1975; WDFW and WWTIT 1993; WDFW 1998, 2000a; Johnson et al. 1999).

HABITAT LIMITING FACTORS IN WRIA 21

Categories of Habitat Limiting Factors used by the Washington State Conservation Commission

The following is a list and description of the major habitat limiting factor categories that are used to organize the Limiting Factors Reports. Although these categories overlap with each other, such that one habitat problem could impact more than one habitat limiting factor category, they provide a reasonable structure to assess habitat conditions within a basin or sub-basin. Within each category are one or more data types that provide a means to assess each category.

Loss of Access to Spawning and Rearing Habitat

This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

Floodplain Conditions

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for floodwaters, sediment, and large woody debris. Floodplains generally contain sloughs, side-channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows. Impacts in this category includes direct loss of aquatic habitat from human activities in floodplains (such as filling), disconnection of main channels from floodplains with dikes, levees, revetments, and riparian roads, and impeding the lateral movement of flood flows with dikes, riparian roads, levees, and revetments. Disconnection can also result from channel incision caused by changes in hydrology or channel aggradation caused by increased sediment inputs.

Streambed Sediment Conditions

Changes in the inputs of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel instability and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Decreased channel stability is often noted by analyzing aerial photographs for widespread channel changes or by measuring scour. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel (through suffocation), and lower the production of benthic invertebrates. As part of this analysis, increased sediment input from landslides, roads, agricultural practices, construction activities is examined as well as decreased gravel availability caused by dams and floodplain constrictions. This category also assesses habitat characteristics, such as bank stability and erosion and large woody debris (LWD) as they relate to streambed and sediment conditions.

Riparian Conditions

Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and large woody debris. Riparian impacts include timber harvest, clearing for agriculture or development, and direct access of livestock to stream channels. This section also examines future LWD recruitment, where data are available, and the abundance and depth of pool habitat.

Water Quality

Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts in a watershed, such as direct animal access to streams.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased low flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or bury spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, and changes in hydrological maturity (vegetation age).

Estuarine and Nearshore Habitat

This category addresses habitat impacts that are unique to estuarine and nearshore environments. Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence on fresh water. These areas provide especially important rearing habitat and an opportunity for transition between fresh and salt water. Impacts include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal saltwater areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, overwater structures, filling, dredging, and alteration of sediment processes. Water quality issues of the estuarine or nearshore environment, such as toxics, dissolved oxygen, and water temperatures are included in this section, as well as the presence of significant baitfish spawning sites. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as marine mammals and birds. The introduction of non-native species specific to the estuary, such as *Spartina*, is included in this section.

Lake Habitat

Lakes can provide important spawning and rearing for salmonids. This category includes impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, the application of herbicides to control plant growth and changes in lakeshore vegetation. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as squawfish (northern pike minnow).

Biological Processes

This category addresses impacts to fish brought about by the introduction of exotic plants and animals and also from the loss of ocean-derived nutrients caused by a reduction in the amount of available salmon carcasses. It also includes impacts from increased predation or competition and loss of food-web function due to habitat changes.

Rating Habitat Conditions

The major goal of this project is to identify the habitat conditions that should be restored or conserved for the best benefit of salmonid production. Often, numerous habitat degradations can be found within a watershed, and some have a greater impact on salmonids than others. To help identify the most significant habitat limiting factors, the Conservation Commission developed a system to rate the above-described habitat limiting factor categories as “good”, “fair”, or “poor”. This is useful to allow comparisons of limiting factors within a watershed, as well as provide the same general standards to rate conditions across the state for this project. These ratings are not intended to be used as thresholds for regulatory purposes. The details and data sources for the standards are described in the Assessment Chapter.

Habitat Limiting Factors in the Quinault Basin

Loss of Access for Anadromous Salmonids in the Quinault Basin

Mount Lawson and Enchanted Valley Salmonid Access Conditions

No information on fish habitat access conditions was found for the Mount Lawson and Enchanted Valley watershed administrative units (WAUs). The roads in this area are limited. Road access only extends to Graves Creek in the upper Quinault Basin and to the North Fork Ranger Station near the North Fork Quinault River, it is likely that salmonid access to areas upstream from those points is similar to historic conditions. Because of the lack of roads in these WAUs, the regions are rated "good" for salmonid habitat access conditions. However, these roads replace natural streambank features in many locations and may impact rearing habitat (discussed in the floodplain section) (S. Chitwood, Jamestown S'Klallam Tribe, personal communication). A natural anadromous barrier exists in the upper Quinault (East Fork) at RM 57 between Graves and O'Neil Creeks (Phinney et al. 1975).

Lake Quinault Salmonid Access Conditions

The tributaries in the Lake Quinault WAU have not been thoroughly surveyed for culvert and other blockage problems. The SSHEAR database identified three stream crossings in Higley, Slide and McCormick Creeks by the North Shore Road where culverts requiring repair have been identified (Appendix 1) (WDFW 2000b). Three additional culverts have been identified as partial upstream passage barriers: one at Gatton Creek, another next to the Quinault Post Office on the South Shore Road, and one at the Rain Forest Resort (R. McConnell, U.S. Forest Service, personal communication). The Gatton Creek culvert at the South Shore Road is not passable to juvenile salmonids. Several streams, such as July Creek, are noted as having upstream passage barriers (R. McConnell, U.S. Forest Service, personal communication, 2001), and an assessment is needed to detail the extent of the problem. No other information regarding historical or current access conditions was found. Due to the lack of a fish habitat access survey and assessment, this region is not rated for salmonid habitat access conditions.

Salmonid Access Conditions in Cook and Elk Creeks

Anadromous fish passage upstream of RM 4.5 in Cook Creek is blocked by the Quinault National Fish Hatchery weir, which started operating in 1968. This limits anadromous fish production to the lower 4.5 miles of Cook Creek and tributaries (Elk and Red Creeks). Anadromous migration into upper tributaries, such as Hathaway and Skunk Creeks, is blocked (Mobbs 1999a), although the weir is not completely fish tight and poses a problem for "pathogen free" surface water (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). No other fish habitat access information was found. Due to a lack of fish habitat access inventories and assessments, this region is not rated for fish habitat access conditions.

Access Conditions in the lower Quinault River

Fish access conditions are unknown in the lower Quinault sub-basin, and this information is a critical need. The SSHEAR database identified two stream crossings of McCalla Creek by Highway 101: one where repair is required and one in "unknown" condition (WDFW 2000b). No other information regarding historic or current access was found. Due to a lack of fish habitat access inventories and assessments, this region is not rated for access conditions. TAG members believe that many culverts exist in the lower Quinault sub-basin, and access assessments should have a higher priority in this area compared to others within the Quinault Basin.

<u>Floodplain Conditions in the Quinault Basin</u>

Mount Lawson & Enchanted Valley Floodplain Conditions

Most of the stream channels in these WAUs are moderately confined or very confined by valley sideslopes and steep terrain. There is a general absence of floodplains in this channel type, and significant off-channel sediment storage is precluded (O'Connor 1999). However, road impacts are a concern. While the roads in this area are limited, they represent a significant artificial structure on the floodplain landscape and the aquatic habitat (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Major stream crossings are bridged, but small or intermittent water crossings have culverts that may not allow juvenile fish passage. A survey of water crossings on the Graves Creek and North Fork Roads during higher flow events is needed. The North Fork Quinault River downstream of Rustler Creek (7.5 miles) and the mainstem Quinault River downstream of Graves Creek (5.8 miles) are discussed below as part of the Upper Quinault geologic floodplain.

Floodplain Conditions in the Lake Quinault WAU

A geomorphic analysis delineated a "geologic floodplain" between the upstream end of Lake Quinault and the mainstem Quinault River downstream of Graves Creek and the North Fork downstream of Rustler Creek. A geologic floodplain is defined as that surface constructed by the present river, as the result of sediment deposition during lateral shifting, migration, or avulsion (cutting new primary channels on the floodplain surface that are distinct from the previous channels), or by deposition during overbank flooding (Church 1992).

This floodplain also includes broad alluvial fans found at the mouths of Finley, Kestner, and Big Creeks, and smaller alluvial fans that have formed where steep tributaries flow off of ridges and onto flat terrain. Watercourses include streams, side channels, and distributary sloughs used by salmonids. Channel and floodplain processes reflect active sediment production from upstream and adjacent mountains and ridges. The gravel-bed braided stream channel indicates high sediment supply rates and high channel mobility.

Along the floodplain margins, debris flows have likely been an important process forming the alluvial fans where larger tributaries flow onto the floodplain (R. McConnell, U.S. Forest Service, personal communication; in O'Connor 1999). It is likely that sediments from these debris flows enter the Quinault and North Fork Quinault Rivers, not directly into the channel but rather from tributary flows or erosion of alluvial fans during channel migration of the Quinault or North Fork Quinault Rivers (O' Connor 1999).

On major type of impact to floodplains within the Lake Quinault WAU is bank armoring. The TAG identified a concern with the North Shore, South Shore, North Fork, and Graves Creek Roads and the amount of bank hardening (rip-rap) present in some locations. A survey of altered streambank sites within the Olympic National Park was conducted in 1996 (Chadd 1997). This survey identified a total of 820 feet of bank armoring on the North Shore Road (RM 41.3); 2,202 feet of bank armoring on the South Shore Road between RM 45.5 and 45.7; 492 feet of armoring at Quinault Bridge (RM 46), and 2,172 feet of bank armoring on the Graves Creek Road between RM 47.4 and 50. This bank armoring is all on National Park lands. The report also identifies an additional 2,461 feet of armoring on the South Shore Road “in two revetments, across from the Park’s mid-channel boundary” (approximately between RM 39 and 45).

The bank armoring impacts total 1.55 miles (8,146 linear feet) on the North Shore, South Shore, and Graves Creek Roads (Chadd 1997). This estimate does not take into account bank armoring projects that might have been undertaken by private landowners in the section between Lake Quinault and the Quinault Bridge near Cannings Creek (RM 37-46). Nearly all bank armoring projects consist of continuous rip-rap revetment; armoring the river bank with a blanket of large, angular quarry stone, contoured over the toe of the bank and up the bank to bankfull level or above (Chadd 1997).

Side-channel and off-channel habitat between Lake Quinault and the Quinault River Bridge serves as a prime spawning reach for sockeye salmon. In years of good returns, about half of the spawning population of sockeye salmon can be found in the side-channel habitats adjacent to the mainstem, while the other half uses the tributary spawning habitat (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). This mainstem reach is also highly important to spring/summer chinook and is used by fall chinook, summer steelhead, winter steelhead, coho, chum, cutthroat, and native char (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Because the bank armoring has been significant, has increased in the last twenty years, and is in an area vital to one stock of salmon, as well as in an area that is important for other stocks, floodplain conditions are rated "poor".

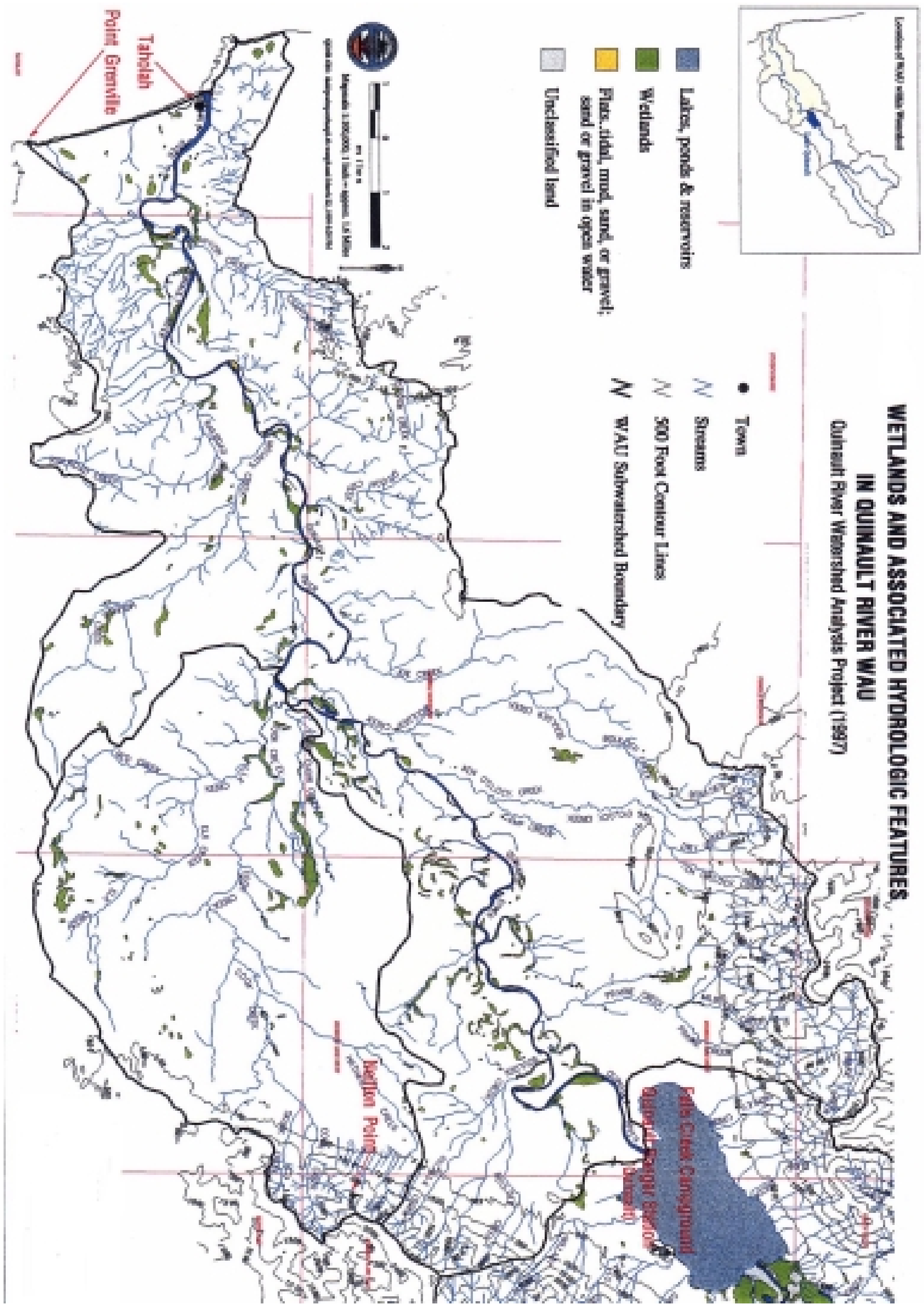
Finley and Kestner Creeks have been dredged and channelized in the past (Mobbs 1999a), and the sediment in the Finley Creek channel continues to be bulldozed as a flood protection measure (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Falls Creek has been channelized downstream of the South Shore Road crossing (R. McConnell, U.S. Forest Service, personal communication). For this reason, these stream reaches are rated “poor” for floodplain conditions, with the note that the extent of impact needs further quantification.

Floodplain Conditions in the Lower Quinault and Cook/Elk Creeks

A geomorphic analysis delineated a "geologic floodplain" in 33 miles of the lower Quinault River, which includes side channels and short reaches of tributary streams near their confluence with the river. Because Lake Quinault traps coarse sediment and wood from upstream sources, the morphology of the lower Quinault River is controlled by interactions between the stream, the floodplain, and the coastal piedmont terrain. The lake also regulates streamflow, which somewhat reduces peak flow potential. The meandering, single thread and somewhat incised channel of the Quinault River reach three to four miles downstream of the lake, is typical of channels with a low to moderate sediment supply (Church 1992, in O'Connor 1999). This reach has stable substrate conditions. The mainstem contains off-channel habitats and river-adjacent wetlands, which are shown in Figure 3 (Mobbs 1999a). Without additional data, it is difficult to rate the floodplain conditions in this area. It is tentatively rated "fair" due to the reduction of instream LWD from historic levels (R. McConnell, U.S. Forest Service, personal communication). Also, road and railroad grades have created and drained wetlands on the Quinault Indian Reservation (Lingley 1999).

The Boulder-Cook watershed analysis identified that road construction, especially in the flatter piedmont terrain, has altered surface and groundwater interactions. Road and railroad grades have blocked the natural flow of water, forming ponds (U.S. Forest Service et al. 1996). Until this potential impact has been better quantified, floodplain conditions in these areas remain a data need.

Figure 3 Wetlands in the lower Quinault sub-basin (Quinault Indian Nation and U.S. Forest Service 1999).



Streambed Sediment Conditions in the Quinault Basin

Mount Lawson & Enchanted Valley Streambed/Sediment Conditions

Only one road exists in each of these WAUs. Road density in the Mount Lawson WAU is very low, with approximately 3 miles of road leading to the North Fork Ranger Station (road density is 0.01 road miles/square mile) (road density data from Lunetta et al. 1997). Road density in the Enchanted Valley WAU is also very low, with approximately 5.5 miles of road leading to Graves Creek (density is 0.07 road miles/square mile) (data from Lunetta et al. 1997).

Graves Creek is considered to have a high susceptibility to bank erosion because past glacial events have deposited thick sediment deposits through which the streams now flow (Lingley 1999), but this is a natural condition. However, the riverbank erosion processes may be advanced by the restrictions placed on the channel by the road system (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Restricted channels increase erosive forces on the margins of the channels (ex. riverbanks opposite roads with armored banks have vectored currents into banks of clay deposits, increasing the rate of erosion). Also, restricted floodplains can exacerbate channel erosion forces by limiting the ability of the channel to spread out and utilize its full width to slow the highest flows. This artificially raises the effective surface elevation of the higher flows, thus reaching a greater surface area of erodible clay bank (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Because of the overall lack of landscape changes in these WAUs, it is not likely that instream sediment conditions have changed appreciably from historic conditions in much of these regions, with the possible exception regarding the concern that increased erosion may have resulted from floodplain impacts. Streambed/sediment conditions are tentatively rated "good" in these two WAUs with the caution that there is a lack of specific information for sediment and streambed conditions other than road density and the floodplain alterations need further analysis.

One source of limited data on LWD was found for the upper Quinault River. Merritt et al. (1999) assessed LWD coincident with developing a benthic index of biological integrity (B-IBI). Their estimates of percent LWD (percent of wetted area with LWD cover) ranged from 75-76% in tributaries of the North Fork Quinault. These counts were the highest levels found among all the streams sampled, which included slightly less than 100 streams located throughout Washington State. The percent of coarse sediment (percent of stream bottom area with substrate larger than sand and fines) was also high (87-89%) in the two sampled tributaries (Kimta Creek and Three Prune Creek) to the North Fork Quinault, indicating that spawning habitat in those tributaries is "good". Other than these estimates (which are difficult to relate to watershed analysis standards), specific data on LWD are lacking for the upper Quinault sub-basin.

Streambed and Sediment Conditions in Lake Quinault Tributaries & Cook/Elk Creeks

Tributaries to Lake Quinault such as Finley and Canoe Creeks, are considered to have a high susceptibility to bank erosion because they flow through thick sediment deposited by past glacial events (Lingley 1999), but this is a natural condition. Falls Creek contains fine sediments from past natural debris flow events (Lingley 1999) and has been channelized downstream of the South Shore Road crossing (R. McConnell, U.S. Forest Service, personal communication). Finley and Kestner Creeks have been dredged and channelized in the past (Mobbs 1999a), and Finley Creek continues to be manipulated near the North Shore Road as a flood control measure (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Sediment aggradation is also present in Big, Inner, and Zeigler Creeks, and these three streams are rated "poor" for streambed stability.

In Canoe Creek, potential sediment delivery associated with bridges, culvert crossings, and road fills is a concern for the U.S. Forest Service 3970-510 road. The U.S. Forest Service 2190-Prairie Creek Road and the U.S. Forest Service 2258 - Quinault Ridge Road are mid-slope roads with large road fills and undersized culverts with the potential for sediment delivery to streams. These areas are recommended for restoration actions.

One source of limited data on LWD was found for the Lake Quinault WAU. Merritt et al. (1999) assessed LWD coincident with developing a benthic index of biological integrity (B-IBI). Their estimated percent of LWD was 9.1 in Ziegler Creek, a tributary to Lake Quinault, a relatively low level compared to other streams, including the North Fork Quinault tributaries. The percent of coarse sediment was relatively low at 34.5%, indicating that spawning habitat is impacted in that reach; however, spawning habitat is good in other areas of this stream (Jean Caldwell, personal observation). Other than this estimate (which is difficult to relate to watershed analysis standards), specific data on LWD are lacking for the streams within this WAU.

The Boulder-Cook watershed analysis identified shallow rapid landslide potential on Quinault Ridge, which contains both the headwaters of various streams in this watershed and some Lake Quinault tributaries. Timber harvesting in the Quinault Ridge was estimated to account for only about 15% of the slope failures. The watershed analysis estimated that the amount of sediments currently reaching stream channels in the Quinault Ridge to be close to natural levels (U.S. Forest Service et al. 1996). Road densities for the Cook-Elk sub-basin were moderate at 2.5 road miles per square mile watershed, which results in a "fair" rating (data from Lunetta et al. 1997). The available road density data for the Lake Quinault WAU appear to underestimate road length, and are not presented here.

Merritt et al. (1999) assessed LWD coincident with developing a benthic index of biological integrity (B-IBI). Their estimated percent of LWD (percent of wetted area with LWD cover) was 6.4 in Cook Creek, a relatively low level compared to two North Fork Quinault tributaries. Other than this estimate (which is difficult to relate to watershed analysis standards), specific data on LWD are lacking for the streams within this WAU. The percent of coarse sediment (percent of stream bottom area with substrate larger than sand and fines) was relatively good at 63.6%, indicating that spawning habitat is probably adequate.

Streambed/Sediment Conditions in the Lower Quinault River

The dominant sedimentation process is stream bank erosion by natural channel processes. The high bank, erodible stream bluffs are a predominant feature in many reaches of the lower Quinault River, including the tidewater portion of the river (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). In addition, where the mainstem of the river is downcutting through undifferentiated glacial drift deposits; there is a potential for sediment input from slope instability. A total of eight miles within the 33-mile lower river was mapped as being within 320 feet of erodible stream bluffs (O'Connor 1999). The Quinault River reach that extends three to four miles downstream of the lake has a low to moderate sediment supply due to sediment catchment in the lake. This reach has stable substrate conditions. Further downstream, the habitat transitions to a glide and run type, while downstream of Prairie Creek, the substrate is more riffle-pool habitat (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Two types of sediment problems have been observed in the lower Quinault River. The first involves suspended fine sediments that are transported downstream from Lake Quinault (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). The ultimate source of these sediments appears to be from upper river tributaries. The number of occasions that the lower Quinault River has been turbid has increased in recent years. This type of suspended sediment problem lasts for a relatively long time. The second problem is the short-term muddy water conditions that result from sediment transfer from lower river tributaries. Although these conditions likely impact salmonids, the impact has not been quantified and remains a data need along with identification of the source of sediment. A large landslide in the mid-1990s nearly blocked the Quinault River channel for a short time and has altered sediment conditions immediately downstream. It is expected that this site will likely supply sediment to the channel for years (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

As late as the early 1990s, there have been unregulated efforts to alter river channel locations and move LWD to allow for boat passage in the Quinault River (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). One channelization effort between Cook Creek and Ten O'clock Creek was conducted with a bulldozer during late summer low flows and on top of newly constructed spring/summer chinook redds (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Road and railroad grades have created and drained wetlands on the Quinault Indian Reservation, although sediment delivery from roads into wetlands and streams was not identified as a chronic problem (Lingley 1999). Road densities for the Quinault River WAU were moderate at 2.0 road miles per square mile watershed, resulting in a "fair" rating (data from Lunetta et al. 1997). The TAG consensus is that the estimated road densities likely underestimate the actual road densities in the Cook-Elk and Quinault River WAUs due to the number of old road spurs and railroad grades present in both regions. For this reason, sediment quantity is rated as "fair" with a note that the rating might be optimistic. Further assessments are greatly needed and include the need for sediment budgets, road inventories and potential impacts, and assessment of spawning gravels and channel stability.

Merritt et al. (1999) assessed percent coarse sediment and LWD coincident with developing a benthic index of biological integrity (B-IBI). The percent of coarse sediment was relatively poor ranging from 4.4 to 20.5 in the sampled reaches of four tributaries to the lower Quinault River, indicating that spawning habitat in those reaches is probably impacted by sedimentation. Their estimated percent of LWD was low for two tributaries (10% and 23.4%) and higher for two other tributaries (46.8% and 54.8), compared to the other streams in the study.

Current instream LWD levels are known to be much lower than historic levels in the lower Quinault River mainstem, where channel-spanning logjams were found in the past. As late as 1933, Conservation Corps crews were removing LWD from the lower river (Workman 1997). Surveys done by Quinault Indian Nation in 1996 on Mounts, Ten O'clock, Camp, Canyon, Railroad, Prairie, and Dry Creeks noted presence of spawning gravels and "fair" to "good" levels of instream LWD. Spawning gravels and LWD levels in Cook Creek appear to be in "good" condition (U.S. Forest Service et al. 1996), but data regarding LWD levels in specific reaches of Cook Creek were unavailable and could not be mapped.

Riparian Conditions in the Quinault Basin

Historically, Sitka spruce, western red cedar, western hemlock, and Douglas fir dominated the riparian vegetation surrounding the Quinault River and its tributaries, and Pacific silver fir probably dominated the high elevation riparian zones (Quinault Indian Nation and U.S. Forest Service 1999). Hardwoods, such as red alder, black cottonwood, and bigleaf maple, were also present, but in much less quantities than in current conditions (Quinault Indian Nation and U.S. Forest Service 1999). The hardwoods were generally located near the mainstem in areas with wet soils or where channel shifts were frequent.

In the 1920s, logging began in the southern area of the basin, using rail. During this time much gravel was removed from the rivers to build the railway system (Quinault Indian Nation and U.S. Forest Service 1999). Early logging typically included removal of trees to the stream edge, leaving no conifer riparian buffer. In the 1970s and 1980s, logging near Taholah and Crane Creek also removed riparian vegetation, even though regulations existed at that time to protect riparian buffers (Quinault Indian Nation and U.S. Forest Service 1999).

Overall, the logging activity has reduced the size and abundance of riparian conifer as well as decreased the number of tree species (Quinault Indian Nation and U.S. Forest Service 1999). Hardwoods have greatly increased because revegetation occurred naturally with few conifers left to provide seed. In the southern portion of the lower basin, the riparian hardwoods are now mature and provide shade, some pieces of large woody debris (LWD), and ecosystem functions (leaf litter, insect habitat). However, the hardwoods are unable to supply key pieces of large wood or restore the volume of historic LWD that once existed (McHenry et al. 1998). In the northern area of the lower

Quinault basin, the hardwoods are much younger and do not adequately shade nor supply LWD (Quinault Indian Nation and U.S. Forest Service 1999).

Current riparian conditions are shown on Map 3. The lower mainstem Quinault River is mostly a mix of "good" and "fair" conditions. "Fair" ratings are given to riparian zones that consist of a mix of hardwoods and conifer or are dominated by young conifer. In the tributaries, "poor" ratings (open or hardwood-dominated) span throughout most of Elk, Mounts, and O Took Creeks, while "fair" ratings are found in Railroad, Canyon, Joe, Camp, Ten O'Clock, and Prairie Creeks (Bill Conway, Quinault Indian Nation, personal communication; and data from Quinault Indian Nation and U.S. Forest Service 1999). North Boulder Creek is a mix of "fair" and "poor", and Cook "Creek is a mix of "good" and "fair" (Map 3).

Near term LWD recruitment is generally low in the Quinault basin downstream of Lake Quinault. Overall, 56% of the sampled segments rate "low", 10% rate "moderate", and 28% rate "high" (Quinault Indian Nation and U.S. Forest Service 1999). Areas with the lowest near term LWD recruitment potential are: Joe, North Boulder, Red, Ten O'clock, Elk, Cook below the hatchery, O' Took, Prairie, Canyon, and Chow Chow Creeks. The "low" near-term LWD recruitment rated areas are shown in Figure 4. Similar data for the upper reaches of the Quinault Basin are not available.

Some of these same tributaries provide very little shade, as well. The areas with the greatest shade problems include Joe, Railroad, Mounts, Cook, lower Elk, and Prairie Creeks (Quinault Indian Nation and U.S. Forest Service 1999). Shade conditions are shown in Figure 5. Data regarding shade conditions in the upper reaches of the Quinault Basin were not found.

In the upper reaches of the Quinault Basin, the Mount Lawson and Enchanted Valley WAUs have generally excellent riparian zones compared to the downstream conditions (Figure 6). In the Mount Lawson WAU, 79% of the riparian buffers in the channel response zones are late seral stage ("good"), with 19% as open or hardwood ("poor") (Lunetta et al. 1997). In the Enchanted Valley WAU, 77% of the riparian in the response channels are late seral stage ("good"), 7% are mid seral stage ("good"), 4% are early seral stage ("fair"), and 10% are open or hardwood ("poor"). The riparian zones in the Lake Quinault WAU are much more impacted, with 34% in late seral stage ("good"), 16% in mid seral stage ("good"), 20% in early seral stage ("fair"), 25% in open or hardwoods ("poor"), and 6% converted to non-forest ("poor") (Lunetta et al. 1997).

The specific reaches that are rated "poor" in the upper basin include most of the mainstem Quinault River upstream of the lake to the confluence with the North Fork Quinault (Map 3). Timber harvest and the presence of a road near the channel have impacted this reach. Other "poor" rated riparian zones include lower Canoe, lower Kestner, lower Finley, and lower Ziegler Creeks, as well as the lower reaches of tributary 21.0494 (Rich McConnell, U.S. Forest Service, personal communication). The riparian conditions in the lower reaches of the North Fork Quinault River and lower Big Creek are "fair". Most other tributaries have "good" riparian conditions, as does the North Fork Quinault River and the upper mainstem Quinault River, which are in the Olympic National Park (Map 3). The tributaries that drain into Lake Quinault have "fair" riparian conditions for a very short stretch between the road and the lake; otherwise, their riparian zones are "good" (R. McConnell, U.S. Forest Service, personal communication).

Current forest practice regulations are much more protective for riparian buffers, but riparian zones that are already degraded will need restoration activity. Restoration should focus on increasing the size and distribution of large conifers to enhance future levels of LWD. The reintroduction of conifers should occur in areas that historically supported conifers, and should be balanced with the increased risk of channel instability, sedimentation, and temperature increases associated with a loss of mature hardwoods.

Pool habitat was generally “good” in the Quinault Basin. The Mount Lawson and Enchanted Valley WAUs are in the Olympic National Park and have been only minimally disturbed. The quantity of pool habitat in the tributaries near Lake Quinault is "good" in Fletcher, Inner, and No Name Creeks, but Big Creek is lacking adequate pool habitat and is rated "poor" (Quinault Indian Nation and U.S. Forest Service 1999). In the lower Quinault basin, the quantity of pools is "good" in Canyon, Mounts, and Railroad Creeks, "fair" in Camp Creek, and "poor" in Dry Creek. In Ten O'Clock and Prairie Creeks, some segments are "good" and others rate "poor" for pool quantity (Quinault Indian Nation and U.S. Forest Service 1999).

Figure 4. Near term large woody debris recruitment potential in the lower Quinault basin (Quinault Indian Nation and U.S. Forest Service 1999).

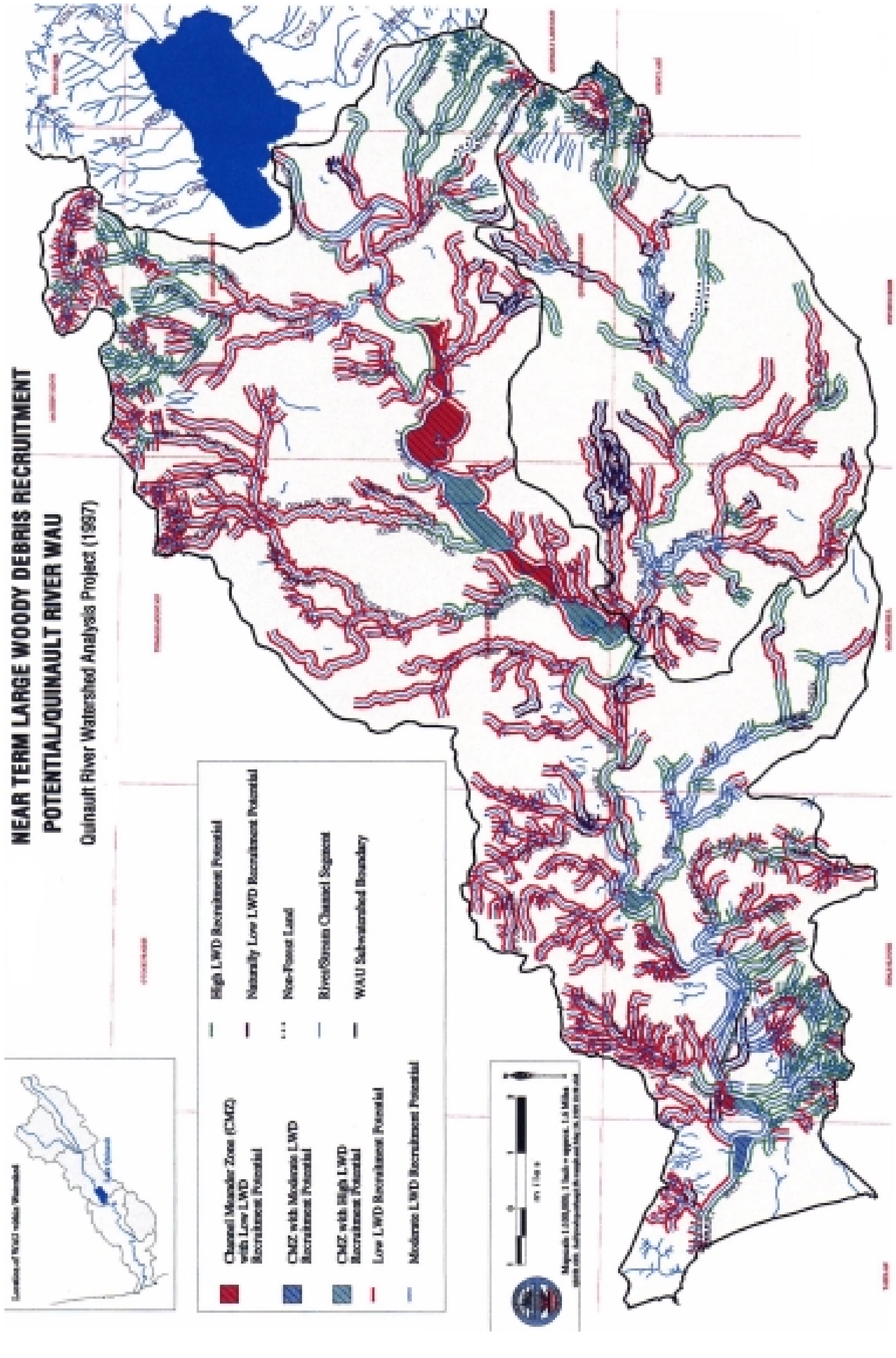


Figure 5. Shade conditions in the lower Quinault basin (Quinault Indian Nation and U.S. Forest Service 1999).

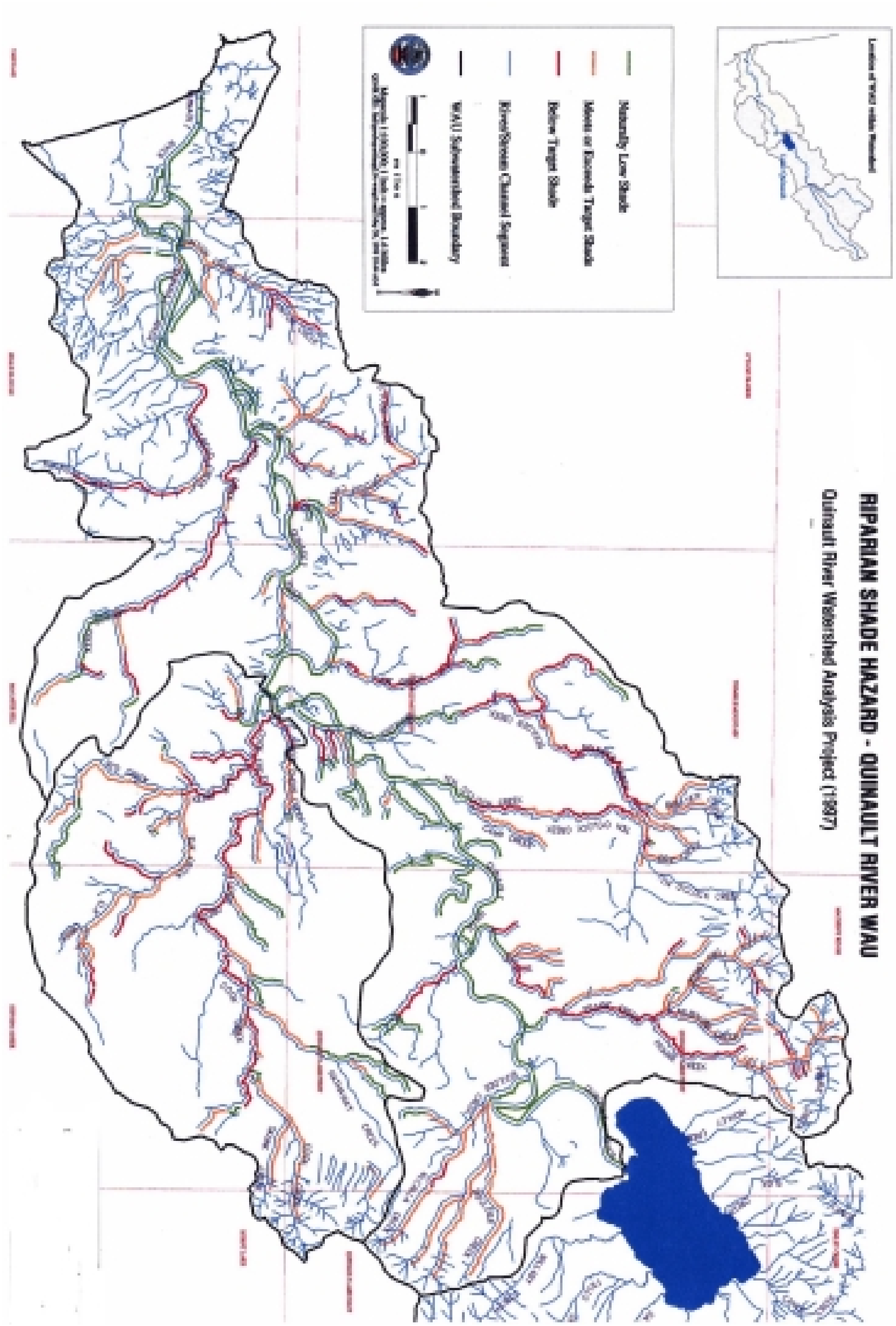
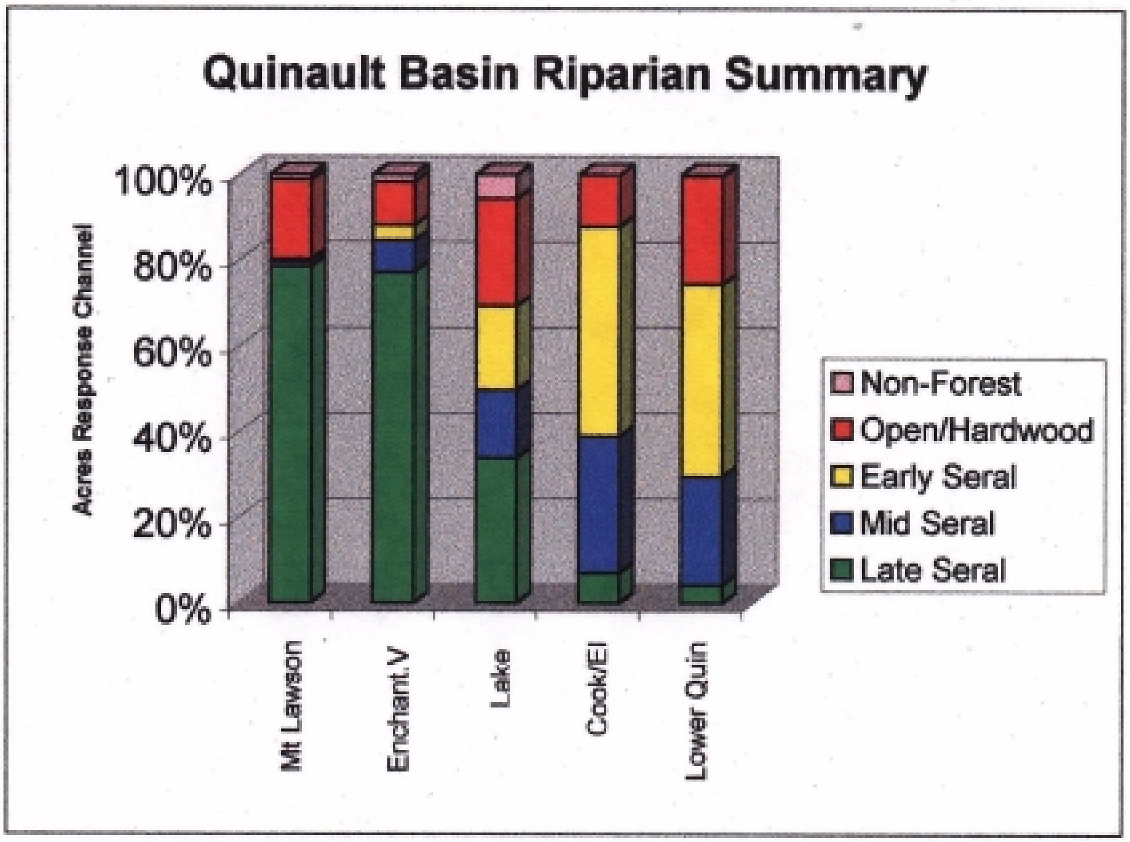


Figure 6. Percent riparian vegetation stages in response channels of the Quinault basin (data from Lunetta et al. 1997).



Water Quality in the Quinault Basin

The Quinault River system is classified by the State of Washington as Class AA for lands outside of the Quinault Indian Reservation.

Mount Lawson & Enchanted Valley Water Quality

The USGS maintained a Hydrologic Benchmark (HBM) site on the North Fork of the Quinault River, which collected water quality data intermittently from 1965 to 1986. Results show typical water temperatures as cool (maximum temperature observed was 13.5°C), minimal turbidity, "good" levels of dissolved oxygen (9.7 mg/l - 15.2 mg/l), low fecal coliform and neutral pH (Mobbs 1999b). This region is rated "good" for water quality.

Water Quality in Lake Quinault WAU Streams

The Quinault Indian Nation collected water temperature data in 1995 at RM 37.5 in the river upstream of the lake. Summer daily maximum temperatures ranged from 10.5 °C to 16.5°C, which results in a "poor" rating for water quality. The U.S. Forest Service has collected temperatures on Falls Creek, and between 1992 and 1996, summer maximum temperatures ranged from 17.5 to 18.0^{o}C, also resulting in a "poor" water quality rating. It is recognized that the low basin elevation and channel width may make it difficult or impossible to attain the DOE Class AA temperature standard. Dissolved oxygen levels are a data need for these streams, especially because of the warm water temperatures.

Lake Quinault stratifies thermally during the spring and summer months (Quinault Dept. Natural Resources 1991). Surface warming begins in spring, and the lake is stratified by June of each year, remaining stratified until October. Surface water temperatures measured in 1989 and 1990 ranged from 2.8 to 20 ^{o}C, while in the hypolimnion, temperatures ranged from 5 to 7^{o}C (Quinault Dept. Natural Resources 1991).

From 1959 to 1980, dissolved oxygen samples were taken by USGS at the gage located at the lake exit (Mobbs 1999b). These measurements ranged from 6.9 to 13 mg/l ("fair" to "good") with pH samples ranging from 6.3 to 7.6. Dissolved oxygen levels measured by the DOE in 1994 ranged from 9.6- 12.12 mg/l ("good"), and pH levels ranged from 7.3 to 8.0 (WA DOE 2001a).

Water Quality in Cook/Elk Creeks

The Quinault National Fish Hatchery withdraws water from Cook Creek and discharges effluent back into Cook Creek. Work completed during 1997 has reduced the amount of settleable solids in the effluent (Mobbs 1999b). The Quinault Indian Nation monitored water temperatures in Cook Creek in 1995 and 1996. Summer maximum temperatures at the hatchery intake (RM 4) ranged from 13.5 to 14^{o}C ("good") and at the mouth ranged from 17.5 to 18^{o}C ("poor"). In an estimate of current riparian canopy cover, most of the mainstem of Cook Creek and lower Chow Chow Creek were below estimated target shade levels or had naturally low shading (Lasorsa 1999). Because of the warm water temperatures, lower Cook Creek is rated "poor" for water quality. Red, Elk, upper Cook, and Skunk Creeks met or exceeded target shade levels (Lasorsa 1999) and these reaches are rated "good".

Water Quality in the Lower Quinault River

The Quinault Indian Nation maintains two temperature-monitoring sites on the mainstem Quinault River at the Highway 101 bridge (RM 33) and near Chow Chow Creek (RM 7.5). The river does not appear to warm appreciably over the 25 stream miles between the lake outlet and the lower monitoring point. In 1995 and 1996, summer maximum temperatures at Highway 101 ranged from 20.5 ^{o}C to 21^{o}C (Mobbs 1999b). Similar results were found from the Department of Ecology periodic sampling of the same reach in 1993 and 1994 (18.5 ^{o}C to 19.1 ^{o}C). At the Chow Chow site, temperatures ranged from 21.5 ^{o}C to 22^{o}C (Mobbs 1999b). Sixty-two percent of the riparian areas along the mainstem Quinault River were found to have conditions where shading would be naturally low; i.e., where the width of the river precludes extensive shading by riparian vegetation (Lasorsa 1999). A total of 21% of the riparian areas met or exceeded target shading, and 17% were below target shading estimates (Lasorsa 1999). Even though the lower river has warm water temperatures, they appear to reflect the natural warming of water from Lake Quinault. This coupled with low levels of poor shading, result in a "good" rating for water quality in the lower Quinault River mainstem.

In lower river tributaries, the water quality ratings are mixed. Summer temperatures at the mouth of South Boulder Creek show maximums ranging from 14.5 to 15^{o}C, which results in a "fair" rating. Many of the lower reaches of Canyon and O'Took Creeks met or exceeded target-shading conditions ("good" rating). Lower Boulder and lower Ten O'clock Creeks were in naturally low shading ("good"), while conditions were generally below target shading ("poor") in the headwaters. Much of the mainstems of Prairie, Mounts, and Railroad Creeks were below target shading levels, resulting in "poor" ratings for these areas. Upper South Boulder and McCalla Creeks met or exceeded target-shading conditions, while lower South Boulder Creek was found to be naturally low in shade (Lasorsa 1999).

<u>Water Quantity in the Quinault Basin</u>

Water Quantity Conditions in the Mount Lawson and Enchanted Valley WAUs

Most of the watershed downstream of Lake Quinault lies at elevations of 500 feet or less, but the mountains that closely surround the lake are 4000 feet or higher. Upstream of Lake Quinault, the elevations reach 6000 feet or greater (Quinault Indian Nation and U.S. Forest Service 1999). Rain-on-snow zones are located in the areas from Lake Quinault upstream (Mount Lawson and Enchanted Valley), and are especially susceptible to flooding. However, most of this land has not been extensively logged and roaded, reducing human-caused impacts to water flow (Quinault Indian Nation and U.S. Forest Service 1999). The hydrologic maturity of these areas is rated "good" (Figure 7). While overall, these areas are in "good" condition, disturbance has occurred near the confluence of the North Fork Quinault River with the mainstem Quinault River. Plus, there are extensive floodplain impacts along the mainstem Quinault River upstream of Lake Quinault to the confluence with the North Fork Quinault. In this stretch, the close proximity of the road to the mainstem coupled with many sites of bank armoring, increase the risk of scour during high flow events. The level of impact of these floodplain problems to stream flow is unknown and is a data need.

Water Quantity Conditions in the Lake Quinault WAU and Lower Quinault

Monthly precipitation varies greatly throughout the year, with average lows of 3" in July to peaks of 24" in December. The total average annual precipitation is 146" at Lake Quinault (Quinault Indian Nation and U.S. Forest Service 1999). The flow gauge near Lake Quinault shows an annual pattern of flow that increases quickly in October, peaks in late November through December, decreases gradually through late April, increases slightly in May and June, then decreases rapidly from mid-June through August (Quinault Indian Nation and U.S. Forest Service 1999). A permanent gauging station is planned on the lower mainstem Quinault River.

Lake Quinault is a natural reservoir that acts as a flood buffer for the lower part of the basin. When peak discharge is normalized and compared to similar nearby drainages without a large lake, the peak discharge for the Quinault River was 31% and 38% lower than the Humptulips and Queets Rivers respectively (Quinault Indian Nation and U.S. Forest Service 1999).

The trend of peak flows has increased in recent decades, but when that increase is corrected for precipitation levels, there is no significant difference between the current and historic peak flows (Quinault Indian Nation and U.S. Forest Service 1999). Precipitation levels are expected to be higher in the near future due to a probable switch in the Pacific Decadal Oscillation (Mantua et al. 1997). These climate shifts occur every 20-30 years, and scientists believe that we have just switched from a warmer, drier regime to a wetter, cooler phase.

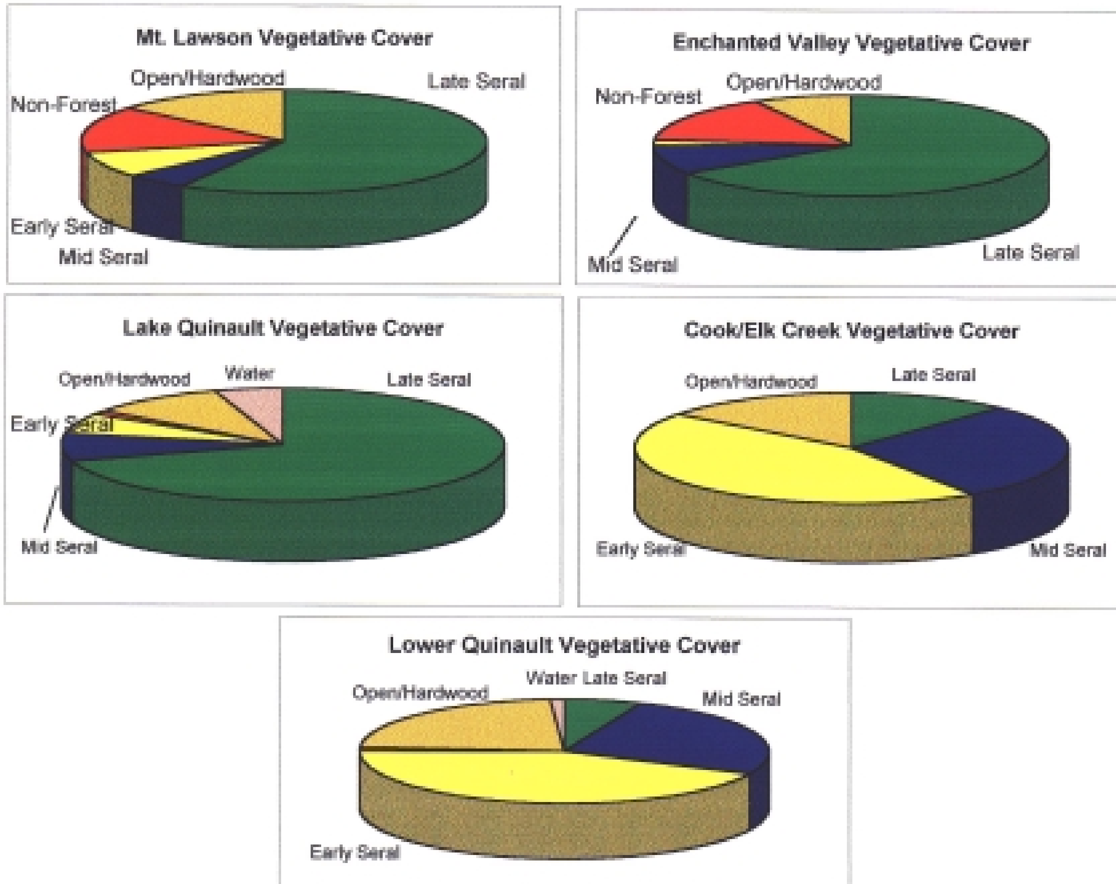
Nearly all the land downstream of Lake Quinault has been clearcut (Quinault Indian Nation and U.S. Forest Service 1999), which increases the risk of high flow and low flow problems. The hydrologic maturity of the lower Quinault and Cook/Elk Creek WAUs is rated "poor" (Figure 7) (data from Lunetta et al. 1997). Based on studies in other basins, the loss of vegetation is thought to decrease the aquifer and wetland storage capacity by disconnecting the wetland hydrologic continuity and altering upland water infiltration and groundwater recharge (Poole and Berman in prep.). Annual water yields increase in the winter rainy season in the first decade after harvest and roading (Harr 1983; Hicks et al. 1991). This can result in an increased magnitude of high flows (Jones and Grant 1996). Roads can increase the peak flow problem by routing surface water more quickly to streams. The effects of roads on increased flow is independent of quantity of forest harvest, but when both activities are combined, the model developed by La Marche and Lettenmaier for the Deschutes River in Washington State (1998) showed a 21% increase in 10 year return floods.

Low flows can also be worsened by the loss of mature conifers. Large trees collect moisture from fog, especially in Sitka spruce zones (Harr 1982) like those found in the Quinault Basin. That moisture is translated back into streams and can contribute an estimated 35% of the annual precipitation under the old growth canopy (Norse 1990).

Several tributaries to the lower Quinault River have low flow problems, and it is not known to what extent these conditions are natural or human-caused. Big and Prairie Creeks have about 19% of dry channel, while Inner Creek has 17% dry channel and No Name Creek has 9% dry channel (Quinault Indian Nation and U.S. Forest Service 1999).

There are no consumptive uses of significant amounts of water within the Quinault Basin (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). The village of Taholah has recently completed a new water system and will be using well water pumped from a site near Canyon Creek.

Figure 7. Hydrologic maturity in the Quinault Basin (data from Lunetta et al. 1997).



Conditions of Lake Habitat in the Quinault Basin

Lake Quinault is the largest lake in this basin (3,729 acres), located between RM 33.4 and RM 36.4. Average lake depth is 133 feet, and maximum depth is 240 feet. The lake is used by spring/summer chinook, fall chinook, chum, sockeye, and coho salmon and steelhead trout for migration, adult holding, and juvenile rearing (Mobbs 1999a). Spawning habitat has been noted at the well-formed gravel deltas at the mouths of major tributaries (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication), but spawning use of these areas has not been observed (Phinney et al. 1975; Mobbs 1999a).

Lake water is completely mixed between November and March with temperatures ranging from 5 to 7°C. The lake stratifies in summer, and water temperatures in the lake attain their maximum value (20 to 21°C) in late July and early August. This is near the upper limit of preferred temperatures for sockeye juveniles, and sockeye juveniles may tend to inhabit cooler water near the thermocline in the warmer months (Foerster 1968, in Mobbs 1999a). It is thought that these warm water temperatures are within a natural range for this lake.

The lake is classed as oligotrophic (low nutrient levels, low productivity). Recent investigations of phosphorus and nitrogen show that concentrations are fairly low, although well within the range reported for Pacific coastal oligotrophic lakes. Total dissolved solids were reported as low, and within the typical range of coastal lakes in the region. Zooplankton levels are reported to be at low density (Mobbs 1999a; Stockner 2000). It is theorized that low numbers of returning adult sockeye have reduced the nitrogen and phosphorus formerly contributed by salmon carcasses upstream of the lake to the lake ecosystem, and that this may be contributing to low sockeye smolt production (Stockner 2000). Concern also exists that increased freshet events (or a series of moderate freshet events) result in delivery of sediments from upstream sources into the lake. Turbidity events have been observed lasting for weeks or months, both in the lake and in the Quinault River downstream of the lake (Mobbs 1999b; S. Chitwood, Jamestown S'Klallam Tribe, personal communication 2000).

The TAG rated the salmonid habitat in Lake Quinault as generally "good" with no significant changes from historic conditions. However, concern exists about shoreline development impacts, residential wastewater, and sediment inputs from upstream. Specific data regarding these concerns are lacking and remain a data need, but compared to other lakes within Washington State, the level of development is relatively low.

Biological Processes in the Quinault Basin

Nutrient cycling is assessed for this report by comparing recent escapement or other abundance levels to historic levels. Only one Quinault stock (spring/summer chinook) has been listed as “depressed” in SASSI (WDFW and WWTIT 1994), but other Quinault stocks have shown large decreases in abundance compared to historic levels. Coho salmon returns from 1936 to 1945 averaged about 42,500 compared to an average of 25,700 from 1978 to 1987 (Lestelle and Blum 1989). Adult returns of sockeye salmon have greatly declined and have shown decreases in return/spawner productivity (Quinault Indian Nation and U.S. Forest Service 1999). From 1908 to 1917, the sockeye salmon run size averaged about 251,000 fish. From 1918 to 1950, runsize averaged 237,000, then dropped to 80,900 fish from 1951 to 1975 (Quinault Indian Nation 1981). In the last two decades, sockeye salmon run size has averaged about 53,000/year and was very low in 1998, 1999, and 2000 (Quinault Indian Nation and U.S. Forest Service 1999; Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

The run sizes for chum salmon and winter steelhead appear to be declining, but the decline is not statistically significant at this time, with the exception of lower river winter steelhead. Also, summer steelhead trout catch estimates appear to be declining, but the drop is not statistically significant. The only salmon and steelhead stock in the Quinault basin that has increased in escapement levels is fall chinook (Quinault Indian Nation and U.S. Forest Service 1999).

To summarize, known data indicate that spring/summer chinook levels are “depressed”, and coho salmon, lower river winter steelhead trout, and sockeye salmon have declined compared to historic levels. Fall chinook escapement levels have increased, and chum salmon, upper river winter steelhead, and summer steelhead abundance have not shown a statistically significant decline, although some concern exists about these stocks. Because about half of the salmon and steelhead stocks are below historic levels, nutrient cycling has likely been reduced and is rated "fair" for the Quinault basin. See the Assessment Chapter for details regarding the rating criteria.

In addition, values of the benthic index of biological integrity (B-IBI) were assessed in tributaries near Lake Quinault, lower Quinault, Cook Creek, and the North Fork Quinault River (Merritt et al. 1999). Levels were low in the tributaries near Lake Quinault (B-IBI=13) and in a tributary in the lower Quinault watershed (B-IBI=13,19,21,23), and are rated "poor" for this parameter. These values compare to indices of 35 in Cook Creek and 39 and 43 in the North Fork Quinault watershed (lies in the Olympic National Park), which are rated "good".

Habitat Limiting Factors in the Queets Basin

Loss of Fish Access in the Queets Basin

Fish Habitat Access Conditions in the Queets River

Because no roads are present in the watershed on the Olympic National Park lands upstream of the Sams River confluence, fish habitat access conditions in the upper Queets watershed are rated "good". Downstream of the Sams River confluence, there are only two bridge crossings of the lower 23 miles of the mainstem Queets River.

The WDFW SSHEAR database lists only one culvert in this drainage requiring repair to restore anadromous access; where the FR 3300/3500 Road crosses Tacoma Creek (Appendix 1) (WDFW 2000b). Potential fish access issues in the tributaries to the Queets River downstream of the Sams River confluence remain a data need, as well as access to off-channel habitats, which are discussed in the Floodplain section. A Washington Dept. Natural Resources culvert inventory is underway and should provide needed data regarding road crossings of anadromous waterways in the Queets Basin. Salmonid habitat access concerns for the Salmon River, Sams River, and Matheny Creek are discussed below.

Fish Habitat Access Conditions in the Clearwater River

While the high road densities in this sub-basin suggest that culvert problems might be a major impact, data are currently lacking for fish habitat access conditions. The Washington Department of Natural Resources is conducting culvert inventories in the Olympic Region, and it is expected that more information will be available in the future (B. Wikene, WDNR, personal communication 2001). The SSHEAR database lists two culverts in this sub-basin requiring repair: where the H-C mainline crosses Donkey Creek and where the C-1100 Road crosses Iskra Creek (Shale Creek tributary) (WDFW 2000b). Without more information, access conditions in the Clearwater sub-basin cannot be rated.

The Washington Dept. of Fish and Wildlife has mapped a total of 49 off-channel rearing habitat areas in the Clearwater River sub-basin for potential enhancement or restoration opportunities. They note that in some cases, fish are absent or present in small numbers in these ponds and wetlands because access to and from the mainstem river is blocked by culverts, old road grades, or logging debris (WDFW 1988). Because this survey has been used to focus restoration efforts, it is recognized that not all access problems identified within it are still problems at this time. Field verification should occur prior to project planning to ascertain current conditions.

Fish Habitat Access Conditions in the Salmon River

An extensive assessment of culverts and barriers to migration in the Salmon River watershed was conducted in 1998 and 1999 (W. Valentine, Quinault Indian Nation, unpublished data 1999). In the lower Salmon River mainstem (RM 0.0 to RM 11.4), no culvert barriers were identified and this area is rated “good” for fish access conditions. On small tributaries to the Salmon River mainstem downstream of Kostly Creek

(RM 10), five blocking culverts were identified. No loss of fish habitat access from culverts or other structures was found in the North, Middle and South Forks of the Salmon River, resulting in a “good” rating for fish access conditions.

Fish Habitat Access Conditions in Sams River & Matheny Creek

The increased incidence of landslides and debris flows has impacted tributary habitat in the Matheny Creek watershed. The upstream extents of migration are variable through time, but has likely been changed from historic conditions, particularly in the Hook Branch, Lower Fork, Middle Fork and South Fork sub-watersheds (U.S. Forest Service 1995). This loss has not been quantified and is not rated. A data need is to more clearly define blockages and their extent of impact.

The Sams River watershed analysis team stated that there are no known human-caused barriers to anadromous fish in the Sams River sub-basin (U.S. Forest Service 1997), resulting in a “good” rating for fish access conditions.

Floodplain Conditions in the Queets Basin

A geomorphic analysis has delineated a “geologic floodplain” for both the Queets and the Salmon Rivers (O’Connor 2000). A geologic floodplain is defined as that surface constructed by the present river, as the result of sediment deposition during lateral shifting, migration, or avulsion (cutting new primary channels on the floodplain surface that are distinct from the previous channels), or by deposition during overbank flooding (Church 1992). Several impacts have been identified in the floodplain habitat in the Queets basin even though specific inventories are generally lacking and remain a data need.

Bank Hardening and Floodplain Roads

Other than the two bridge crossings noted previously, there are essentially no roads within the Queets floodplain downstream of RM 10, except in the community of Queets. The Queets River Road runs parallel to the floodplain from RM 10 to RM 23. Even though this road is on the river terrace or the toe of side slopes for most of its distance, impacts to the Queets River have occurred, such as washouts and riparian alterations (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). A major problem exists along the Queets River Road on a hillside just west of the Matheny Creek Bridge. The road travels upslope just before dropping down to cross Matheny Creek, and this slope is believed to be highly unstable (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). A large vein of glacial clay is at the base of the slope, providing a major source of fine sediment to the river for the last ten years. This causes turbidity in the lower Queets even during times when no other source of turbidity is evident. The turbidity can be seen for at least five miles downstream (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). It is believed that the operation and maintenance of the road is a major contributor to the unstable hillside. Bank armoring is much less of a concern in this region. This results in a “poor” rating for this reach of the Queets River floodplain (between Sams River and the Salmon River).

Floodplain issues in Matheny Creek are confined to two bridge crossings that constrict the river channel at the point of crossing. A short distance (140 feet) of bank hardening was identified in Matheny Creek at RM 0.4 (Chadd 1997), but is believed to have little to no impact. No impacts of roads on floodplains or side channels were identified (R. McConnell, U.S. Forest Service, personal communication 2001).

The Sams River watershed analysis team did not identify any impacts of roads to the floodplain (U.S. Forest Service 1997). This is most likely due to the fact that only the Queets River Road lies near the Sams River floodplain, and only one stream crossing (a bridge) exists over the Sams River between RM 0.0 and RM 5.0, which is the boundary to Olympic National Park.

The Salmon River watershed analysis team did not identify any substantial impacts of roads to the floodplain, and no evidence that land use actions have isolated off-channel or floodplain habitats (Quinault Indian Nation 2000). Chadd (1997) identified one site on the Salmon River at RM 0.4, with approximately 250 feet of bank hardening (Queets River Rd. crossing of the Salmon River), which is a very low level of impact.   This results in a "good" floodplain rating for the Salmon River.

In the Clearwater sub-basin, no assessment of the impacts of roads and bank hardening on floodplains and associated habitat features has been found.   However, documentation of filled wetland areas and associated culverts has been used to prioritize restoration efforts (WDFW 1988). Impacts from past land use and roads have likely reduced access to off-channel habitat, but they need to be quantified. At this time, it is unlikely that floodplain habitat conditions would be rated "good", but until the impacts are quantified, no rating is assigned.

Loss of Off-Channel Habitat Due to Sedimentation and Lack of LWD

Conditions in the Queets River upstream of the Sams River are very similar to historic conditions, due to the relatively small impact of human settlement prior to the establishment of the National Park (McLeod 1984). It is expected that the condition of off-channel habitats in that reach would also be similar to historic conditions.   However the timber-managed tributaries, such as the Clearwater River and tributary streams, the Salmon, and Sams Rivers, and Matheny Creek have experienced increased sediment inputs and loss of LWD recruitment. It is unknown whether the impacts in the timber-managed tributaries have resulted in changes in off-channel habitat in the lower mainstem Queets, and this remains a data need.

It has been documented that off-channel habitats in the lower Clearwater River are an important habitat component for coho salmon and cutthroat trout (Cederholm and Scarlett 1982, Peterson 1980, Blair and Chitwood 1996). In the Clearwater sub-basin, an estimated 20 to 35% of the annual coho smolt production originates from off-channel areas (Peterson and Reid 1984). In several recent years, more than half of the coho smolts produced in the Clearwater sub-basin are emigrating from off-channel habitats as compared to tributary and mainstem habitats (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Studies in the Clearwater sub-basin have shown that off-channel habitats such as spring-fed riverine ponds and wall-based channels are important refuge areas for coho and cutthroat juveniles displaced by high winter flow events typical of Olympic Peninsula Rivers (Peterson 1980, Cederholm and Scarlett 1982, Peterson and Reid 1984; Scarlett and Cederholm 1984). Juvenile steelhead trout appear to also migrate from mainstem river habitats to tributary streams during the high flow period (Cederholm and Scarlett 1981, 1982). Cederholm and Reid (1987) state that disruption or blockage of small winter refuge channels can reduce coho smolt survival. Experiments have shown that habitat enhancement in these small channels can result in an increase in coho juveniles' overwinter survival and growth (Cederholm et al. 1988; Cederholm and Scarlett 1991).

The Matheny Creek watershed analysis team noted that the lower 2.7 miles of Matheny Creek is the area in the watershed with a well-developed floodplain. Riparian timber harvest and lack of LWD have contributed to channel widening. This, coupled with increased sediment yields in headwaters regions, has caused aggradation, which in turn, has contributed to loss of off-channel habitat (U.S. Forest Service 1995). Off-channel habitats are not common in Matheny Creek or in the Sams River; which increases the importance of those that do exist (Bechtold 1992).

In the Sams River, the watershed analysis team identified a concern that increased sediment loads from hillslope and road failures have also decreased access to off-channel habitats in low-gradient sections of the mainstem Sams River (U.S. Forest Service 1997). They classified off-channel habitat as "at risk" in the response reaches of the lower Sams River and "not properly functioning" in the response reaches in the upper Sams River. The lower two miles of the Sams River mainstem are in fairly good condition (R. McConnell, U.S. Forest Service, personal communication). Except for the lower two miles, the response reaches are rated "poor" for floodplain conditions.

In the Salmon River watershed, the area where off-channel habitat is expected to be most common is in the lower mainstem downstream of RM 10. While most of the mainstem Salmon River riparian areas currently have a low recruitment potential rating for LWD, many of the tree sizes are approaching the diameter (12") where they would be classified as "medium" size and rated as good recruitment potential. The watershed analysis team did not identify any areas where high sediment loads or lack of LWD decreased access to off-channel habitats. However, they did recognize that interactions between in-channel LWD and streamflow were a factor creating both channel shifting and off-channel habitats (Quinault Indian Nation 2000).

A high priority restoration need for the entire Basin is to maintain existing functional off-channel habitat and to restore lost or degraded habitat. A data need exists to identify floodplain impacts and prioritize them according to the degree to which salmonid production is lost.

Streambed and Sediment Conditions in the Queets Basin

Streambed and Sediment Conditions in the Queets River and Smaller Tributaries

Little information was found about past or present instream sediment conditions in the Queets River. Because the river upstream of the Sams River confluence (RM 23.5) has been part of Olympic National Park since 1940 at the latest (park boundaries changed several times between 1900 and 1950), instream sediment conditions are expected to be similar to historic conditions (MacLeod 1984). Only two bridge crossings and very little streambank erosion were found in the lower Queets Corridor, an area within the Olympic National Park boundaries (RM 8 - 23.5) (Chadd 1997). No information was found about streambed and sediment conditions downstream of RM 8. Overall road density in the Queets Corridor North WAU was estimated at 2.5 mile of road/sq.mi. watershed (data from Lunetta et al. 1997), which results in a "fair" rating. However, sediment assessments are needed for this area.

Instream LWD data are scant for tributary streams within the Queets Corridor WAU. Coal Creek (a tributary to the middle Queets River) and Harlow Creek (a tributary to the upper Queets River) have "good" levels of instream LWD, with 4.4 and 7.6 pieces/channel width, respectively (Hatten 1994). Because both of these study sites were in unmanaged timber stands, these numbers can give some indication of historic LWD levels. In the lower Queets sub-basin, Elk Creek has shown a significant reduction in the number of pieces of old growth LWD (31 pieces per 100 m in 1982 to 22 pieces per 100 m in 1993), while the level of second growth LWD has remained about the same (McHenry et al. 1998). Other than these three sites, an assessment of LWD is a data need.

Streambed and Sediment Conditions in the Clearwater Sub-Basin

The impacts of timber harvest and road building on the rate of landslides and the effects of road sediments and instream sediment conditions in the Clearwater River have been well studied (for example, Cederholm and Lestelle 1974; Fiksdal 1974; Edie 1975; Tagart 1976; Cederholm et al.1977; Cederholm et al.1978; Reid 1981). Cederholm et al. (1981) state that significant amounts of fine sediments were found at that time to be accumulating in spawning gravels in sub-basins with high road densities. This accumulation was highest in sub-basins where the road area exceeded 2.5% of the watershed area. There is a rapid decrease in salmonid egg survival as levels of fine sediment increase over the background levels (estimated at approximately 10%). Cederholm and Reid (1987) state that the mortality of coho salmon in the Clearwater River that was forestry related, was primarily due to the increased sediment load from landslides and surface erosion from heavily used logging roads, and from reductions in winter refuge capacity due to stream blockages, riparian alterations, and habitat destruction.

The rate of timber harvest and associated road use in the Clearwater sub-basin may be less at the present time than during the 1970s and 1980s (Felt 1985; WDNR 1997). It is unknown whether the amount of, or rate of, landslide and debris torrent events has changed in the past two decades. This is a data need. In 1979, debris torrent events were caused by road fill failure and road and landing sidecast entering the stream channel in a Snahapish River tributary (Octopus-B Creek) (Scarlett and Cederholm 1996). Cutthroat trout population monitoring showed an initial extreme impact from the event, followed by partial recovery of populations, and eventual population numbers of half their pre-torrent level. The largest slide events in the last decade have been the Suzie Creek and Sollecks events. Both impacted the stream of origin as well as the mainstem Clearwater River and spread large amounts of sediment downstream in a short period of time (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Both areas were important spawning habitat reaches prior to the slides. Road fill placement and past clearcutting activities are thought to be contributing factors to the destabilization of the basin sideslopes and resulting landslides (Serdar 1999).

Current sediment concerns in the Clearwater River sub-basin and the north side of the Queets River include large (deep) road fills with small culverts on toe slope roads and mid-slope roads that cross areas with a high potential for mass wasting (B. Wilkene, WA DNR, personal communication, 2001 and R. McConnell, U.S. Forest Service, personal communication, 2001). An additional problem is steep switch-backed tie roads between mid-slope roads and ridge spurs; examples include roads C2040 and C2070. On the Queets Ridge WDNR lands, roads make a contribution to instream sediment in places. Examples of roads that contribute sediment in this region include the C-3140, 1200, 1300, Q 3200, C3200, C2030, and C2000 roads. The upper segments of the Q 3000 roads are a concern due to large (deep) road fills and small culvert sizes, although these are less of a problem than the roads identified above. On DNR and U.S. Forest Service lands in the upper Stequaleho drainage, two “half-bridge” log stringer structures at the headwaters of the Stequaleho have the potential to fail in the future due to age. Some restoration activity has occurred for sediment problems in the Clearwater sub-basin, for example, sidecast removal projects have been completed in the Miller Creek and Christmas Creek watersheds.

Road densities in both the lower and upper Clearwater WAUs are high, at 3.7 and 3.2 miles of road/sq. mi watershed, respectively (data from Lunetta et al. 1997). This results in a "poor" rating for sediment quantity. Although past data indicates that sediment quality has been "poor", current conditions are unknown, and remain a data need.

A data need is whether, and if so where, current levels of fine sediment inputs are similar to those identified in the past, or whether reductions in timber harvest and road use have reduced the magnitude of the fine sediment problem. Also unknown is the extent of problems caused by the lack of road and culvert maintenance. Another data need is assessment of the extent to which an increased rate of coarse sediment contributions from management-related landslides is contributing to aggradation and higher sediment loading in the mainstem Clearwater River (S. Chitwood, Jamestown S'Klallam Tribe, personal communication 2000).

Levels of instream LWD are unknown. In the middle Clearwater, Snahapish River has shown an increase in the number of pieces of old growth LWD (56 pieces per 100 m in

1982 to 63 pieces per 100 m in 1993) (McHenry et al. 1998), but no other studies have been found. This is another data need.

Streambed and Sediment Conditions in the Salmon River

The Salmon River watershed analysis team noted that timber harvest and road construction have increased the amounts of sediment entering the Salmon River tributaries over natural levels, which results in a "poor" rating for sediment quantity. Land management has resulted in an increase in landslides, with timber harvest accounting for 51% of the landslides and roads causing about 25% of the mass wasting (Quinault Indian Nation 2000). Mid-slope roads and road washouts are a major concern, and generally include mid-slope roads with undersized culverts and either existing or potential sidecast failure. Specific issues exist for roads 2140-090, 2140-030, 2191-091 (Quinault Indian Nation 2000). The 2120-030 Road on the south side of the North Fork Salmon River is a mid-slope road in unknown condition. The 2120-022 Road is an abandoned mid-slope road in disrepair with undersized culverts. The 2140-131 and -151 Roads have existing sidecast failure with the potential for more failure. The 2120 Road has undersized culverts with direct delivery potential to the headwaters of the South Fork Salmon River.

Sediment quality appears to be "good" in the lower Salmon River with abundant spawning gravel and very little embeddedness (Quinault Indian Nation 2000). Throughout the remainder of the Salmon River, fine sediments are only mentioned as a problem in the upper South Fork Salmon River. The lower South Fork Salmon River is rated "good" for sediment quality. Erosion from clearcut areas is thought to be a potential problem in the Middle Fork Salmon River (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Steep slopes with little riparian vegetation were noted, and at the base of each clearcut, was an accumulation of soil, deciduous leaf litter, and other organic material at depths of one to two feet. This would likely provide fine sediment even in times of only moderate rainfall (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Unstable stream banks have been noted throughout the North Fork Salmon River, but are uncommon in the Middle Fork and South Fork (Quinault Indian Nation 2000). The watershed analysis team rated the North Fork as “not properly functioning”, and all other sub-basins as “properly functioning” for streambank condition. Overall, surface and hillslope erosion is low.

Levels of instream LWD were inventoried in the North Fork Salmon River, and all sites measured less than 1 piece/channel width, resulting in a "poor" rating (Quinault Indian Nation 2000). The lack of instream LWD is the result of stream cleaning efforts that occurred in the 1970s. In 1972, 2.1 logjams per mile were recorded in the North Fork, Middle Fork, and South Fork Salmon Rivers, but some of these were removed in 1973. In 1995, a "fair amount" of LWD existed in the Middle Fork Salmon River along with several sites where big pieces of wood had collected in piles that were not quite jams (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). No other quantitative estimates of in-stream LWD levels were found for the Salmon River, but watershed analysis mentioned that levels are low in the South Fork and "lower than desired" in the lower Salmon River (Quinault Indian Nation 2000).

For the Sams River, Matheny Creek, and the Salmon River, watershed analysis teams recognized that for some reaches that have more confined channels or steeper gradients, LWD retention will be naturally limited (U.S. Forest Service 1995, 1997; Quinault Indian Nation 2000).

Streambed and Sediment Conditions in the Sams River Sub-Basin

Landslides are a major problem in the Sams River watershed with 235 identified, based on analysis of aerial photos between 1939 and 1993 and on observations in 1996 to 1997 (U.S. Forest Service 1997). The density of landslides, both natural and management-related, is fairly high in the Sams River and North Creek, and is lower in Phelan Creek. Of the mass wasting and surface erosion events associated with management, the common triggering mechanisms are slope failures in clearcuts, road fill failure, and road drainage delivery of fine sediments. Of particular concern are sidecast roads and landings constructed in steeper terrain, which generally occurred during the 1960s to 1980s. It is expected that recent and planned road decommissioning efforts will reduce the magnitude of this problem (U.S. Forest Service 1997).

Road sediment concerns in the Sams River sub-basin include midslope and toe-slope roads with known sidecast failure and drainage (plugged culvert) problems at risk of sediment delivery. A road abandonment plan is in place for this watershed. The 2180 Road out to milepost 9.3 has several locations that have known culvert problems, including large fills and undersized culverts.

Debris flows are a common form of landslide with high densities in North Creek (7.6 events/sq.mi.), upper Sams River (6.2 events/sq.mi.), and lower Sams River (6.1 events/sq.mi.). A lower density exists in Phelan Creek, 1.6 events/sq.mi. (U.S. Forest Service 1997). The excess sedimentation results in a "poor" rating for sediment quantity. The excess sediment may contribute to disconnected off-channel habitat and lower pool quality habitat.

Substrate conditions were classified as "properly functioning" in the Sams River Watershed Analysis (U.S. Forest Service 1997). This results in a "good" rating for sediment quality. However, they listed LWD as "not properly functioning" in the response reaches for both the lower and upper Sams River, resulting in a "poor" rating for this parameter.

The upper Sams River response reach is rated “poor” for channel stability due to bank erosion and channel widening resulting from a stand-replacement fire and subsequent riparian harvest. Current riparian conditions are second growth. The lower Sams response reach is rated “fair” for channel stability because of mature riparian stands in many areas, which will improve future LWD recruitment. Stream gradients and channel confinement will naturally limit LWD retention in many reaches of the Sams and Matheny sub-basins (R. McConnell, U.S. Forest Service, personal communication 2001).

Streambed and Sediment Conditions in the Matheny Creek Sub-Basin

There are large numbers of in-channel disturbances in Matheny Creek tributaries. Management-related mass wasting events include coarse and fine sediment inputs from channel-adjacent landslides and shallow rapid landslides triggered by clear-cuts or roads (U.S. Forest Service 1995). In a landslide inventory based on 1962 to 1993 aerial photos, the majority of debris flows were found to be management-related. Of these, 56% were determined to be associated with roads and 44% with harvest units. Road-related problems include fill and sidecast failure and fine sediment delivery, and are often associated with mid-slope locations. It was noted that management-related landslides tended to be larger and less confined than natural landslides, with a corresponding higher delivery of sediments (U.S. Forest Service 1995). This results in a "poor" rating for sediment quantity for Matheny Creek.

Specific examples of sediment concerns in Matheny Creek include the WDNR Q1800 Road, which has medium to large road fills, small culvert sizes, and road segments in close proximity to Matheny Creek with a high potential for sediment delivery. The 2160 and 2140-200 roads are identified as toe slope roads with undersized culverts and road fills with risk of sediment delivery. The 2170-020 road is a midslope road with a couple of large road fills at risk of sediment delivery if a slope failure occurs. The West Boundary Road has several places where several deep road fills and small (five foot) culverts create the potential for sediment delivery.

Deposition of fine sediment and embedded substrates indicate degraded spawning habitat in the unconfined, lower-gradient reaches of Matheny Creek (RM 0 - 2.7) (U.S. Forest Service 1995). For this reason, sediment quality is rated "poor" in this reach. Sediment quality is fairly good in many other areas of Matheny Creek, due to high channel transport capacity. Levels of instream LWD have been listed as low for the lower 2.7 miles of Matheny Creek (Bechtold 1992; U.S. Forest Service 1995). This area is also rated "poor" for LWD.

The Matheny Creek watershed analysis team summarized that while the frequency, rate, and magnitude of sediment inputs to streams were likely to be reduced in the future from current levels, sediment inputs will be higher than background rates for some time. Habitat areas most susceptible to degradation include the upper tributary drainages, which will continue to receive debris torrents, and the lower 2.7 miles of Matheny Creek, where all sediment is eventually routed (U.S. Forest Service 1995). Recent road stabilization and decommissioning projects are addressing these issues (R. McConnell, U.S. Forest Service, personal communication 2001).

Riparian Conditions in the Queets Basin

Riparian Conditions in the Queets River and Smaller Tributaries

Riparian conditions in this watershed differ between National Park lands and other landowners. Riparian conditions in the Queets River on National Park lands are described as a "...complex assemblage of riparian forest patches..." (Abbe and Montgomery 1996). This reach can be considered an approximation of undisturbed conditions, due to the relatively small amount of timber harvest associated with homesteading along the Queets Corridor prior to 1940, and National Park status since that time. Four coniferous and three hardwood species were found to contribute to functional in-channel LWD.

Outside of the Queets Corridor and Olympic National Park lands upstream of the Sams River, riparian areas in Queets mainstem tributaries and in the lower Queets mainstem (downstream of RM. 8) will show effects of, and recovery from, past timber harvest practices. These impacts will vary by decade of harvest as well as between landowners. The impacted tributaries include the Clearwater, Sams, Matheny, and Salmon sub-basins.

Riparian condition summaries generated as part of watershed analysis are presented below for the Salmon, Sams, and Matheny sub-basins, because they are the most precise data available. For other areas, larger-scale satellite imagery assessments of riparian condition on a WAU-scale are presented (Lunetta et al. 1997). It is recognized that this reduces the precision of the results. Because of this, the larger-scale analyses are used to rate areas only when watershed analysis is not available, although all results for the WAU-scale analyses are presented in Figure 8.

"Poor" ratings were assigned to riparian areas lacking trees or dominated by hardwoods. "Fair" ratings were assigned to young conifer or mixed hardwood/conifer riparian areas. "Good" ratings were given to riparian buffers dominated by mature conifers. See the Assessment Chapter for a full discussion on the standards used in this report.

The Queets Corridor North WAU comprises the mainstem Queets River and smaller tributaries from just downstream of Coal Creek (approximately RM 25) to the mouth of the Queets River. (The Queets Corridor extends from RM 8 to RM 24.) The lower seven miles of the mainstem Queets and upper portions of tributary streams are on U.S. Forest Service, Quinault Indian Nation, Washington DNR, or privately owned lands. The next 18 miles of the mainstem Queets and lower reaches of tributary streams are on Olympic National Park lands. This makes data interpretation somewhat difficult. Riparian conditions in this WAU consist of 36% "good", 26% "fair", and 28% "poor" reaches, with an additional 10% as non-forest lands (Figure 8) (data from Lunetta et al. 1997). McKinnon, Tacoma, Fish, Ticket, and Boulder Creeks flow off of Washington Dept. Natural Resources lands and through the Park corridor before entering the Queets River. Most are also crossed by the Queets Ridge Road system and have experienced riparian impacts (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Summary information from the Tshletshy Ridge WAU and the Mount Queets WAU are presented in Figure 8. The Mount Queets WAU lies completely within the National Park, and the Tshletshy Ridge WAU consists of mostly National Park lands, but also includes the Sams River watershed. Both these WAUs are rated as "good" because of the relative lack of land use disturbance. The open/hardwood category in the summary information likely reflects high country glacial areas that are naturally open. A discussion regarding the riparian conditions in the Sams River is below.

Pools were counted in the mainstem Queets River between RM 25.4 and 41, with 16.3 pools per mile (Abbe and Montgomery 1996). Numbers of pools were also assessed in eleven Queets River tributaries (Quinault Indian Nation, unpublished data, 1990 to 1995). Most of these were rated "fair" to "good" with only one tributary rating "poor" (North Fork Mud Creek). Streams that rated "good" for percent pool habitat are Elk, McKinnon, Mud, North, and the East and West Fork Tacoma Creeks. Tributaries that rated "fair-good" include Harlow, Paradise, Phelan, and Tacoma Creeks. No other data were found regarding pool habitat in the mainstem Queets River.

Riparian Conditions in the Sams River Sub-Basin

The native riparian vegetation along the Sams River transitions from a Sitka spruce community in the lowlands to a mountain hemlock community in the uplands (U.S. Forest Service 1997). Since 1900, timber harvest has removed about one third of the late successional and old growth forest in this watershed, with moderate conversion of mature conifer to hardwoods or young conifer riparian. This has resulted in a loss of LWD, which coincident with excess sedimentation, results in a loss of deep pool habitat and off-channel rearing areas. Although specific riparian vegetation age and type were not available, riparian habitat in the response reaches of both the lower and upper Sams River was rated as "not properly functioning" in the watershed analysis (U.S. Forest Service 1997), or "poor" in our report. The transport reaches in the lower Sams River were rated as "at risk" ("fair"), while in the upper reaches, transport reaches were rated as "properly functioning" ("good").

Most of the riparian impact has resulted from a conversion of mature or old growth conifer to young conifer, reducing near-term LWD recruitment potential (U.S. Forest Service 1997). Current riparian conditions are most impacted in the lower Sams River with 6% rating "poor", 34% rating "fair", and 60% rating "good". North Creek consists of 70% "good" riparian lengths, 26% "fair", and 4% "poor", while both Phelan Creek and upper Sams River have 80% "good", 17% "fair", and 3% "poor" riparian areas (U.S. Forest Service 1997).

Near-term LWD recruitment potential is most reduced in Phelan Creek with 49% of the reaches rating "poor", 16% rating "fair", and 35% rating "good" (U.S. Forest Service 1997). North Creek near-term LWD ratings are 14% "poor", 51% "fair", and 35% "good". Lower Sams River has 12% of the reaches rating "poor" for LWD recruitment, 26% rating "fair", and 63% rating "good". Upper Sams River is 79% "good", 12% "fair", and 9% "poor" (U.S. Forest Service 1997).

Pool quality was rated as "properly functioning" in all reaches except for the response reaches in the upper Sams River, but pool frequency was rated "not properly functioning" in the response reaches throughout the Sams River (U.S. Forest Service 1997).

Riparian Conditions in the Salmon River Sub-Basin

Sitka spruce, Douglas fir, and western red cedar dominated the historical riparian vegetation, but with past land management, some conversion to younger conifers and hardwoods has occurred. A greater ratio of hardwoods to conifers than historically present is found in many riparian stands, although hardwoods have always been a component of riparian stands along the mainstem Salmon River and larger tributaries. Some recovery of the near-term LWD recruitment potential can be seen; the Salmon River watershed as a whole is rated "high" for 62% of the riparian reaches "high", "low" for 30%, and "medium" for 7% of the riparian reaches for near-term LWD recruitment potential (Lasorsa 2000). Analyzed by sub-watershed, the North and Middle Forks have "good" recruitment potential, the South Fork has "moderate" recruitment potential, and the lower Salmon River has "low" potential for near term LWD recruitment potential (Lasorsa 2000).

Canopy closure in the lower Salmon River sub-basin riparian areas consists of 46% at or above target levels, 19% below target levels, and 35% “naturally low”. Most of the “naturally low” canopy closure is found along the lower mainstem of the Salmon River, where stream width limits the effectiveness of riparian shading (Lasorsa 2000).

However, there are some problem areas, predominately in the lower Salmon River and the South Fork Salmon River sub-basins. Most of the riparian problems in these two sub-basins occur in the tributary streams, where past harvest has resulted in small conifers in riparian areas, particularly in the tributaries’ upper reaches (Lasorsa 2000). This conversion has caused a reduction in near-term LWD recruitment, which is "low" for 42% of the riparian area in the lower Salmon River sub-basin and "low" for 25% of the riparian area in the South Fork Salmon River sub-basin. Because the current conditions consist mostly of young conifer, the rating assigned to the tributaries in these streams is "fair". The mainstems are rated "good" because riparian buffers were left along these during timber harvest.

In the North Fork and Middle Fork Salmon Rivers, intact riparian buffers are at least 100 feet wide along most of the mainstems (Quinault Indian Nation 2000 draft). Tributaries to these mainstems tend to have old growth riparian conditions in their lower portions with timber harvest impacts, including reduced shading, in their upper reaches. However, 79% of the South Fork sub-basin riparian areas meet target shading levels, as does 85 % of the Middle Fork riparian areas, and 80% of the North Fork riparian areas (Lasorsa 2000).

Pool habitat within the Salmon River watershed varies considerably. In the North Fork Salmon River, the percent pool habitat is rated "good" in the lower 1.7 miles and "fair" from RM 1.7-6.1 (Quinault Indian Nation 2000 draft). However, pool frequency (pools per channel width) is rated "poor" in the lower North Fork. In the Middle Fork Salmon

River, both percent pool habitat and pool frequency are rated "poor". In the lower South Fork Salmon River, percent pool habitat is rated "good" and pool frequency is rated "fair". However, in the upper South Fork Salmon River (upstream of the 2120 Road crossing), both percent pool habitat and pool frequency are rated "poor".

Based on the pool and LWD surveys in the Queets River mainstem on Olympic National Park lands discussed previously (Abbe and Montgomery 1996), and because there is fairly good evidence that LWD levels are lower than their potential in the lower mainstem Salmon River, the watershed analysis team hypothesized that the area of LWD-associated pools is less than what could potentially be present.

Riparian Conditions in the Clearwater River

Specific riparian conditions, shading levels, and LWD recruitment potentials are not known for this sub-basin, but some general data were found on the WAU level (Figure 8). In the lower Clearwater River (downstream of the Snahapish River confluence), "good" riparian conditions comprise about 54% of the buffers, with "fair" conditions in 27% and "poor" conditions in 19% of the buffers (Figure 8) (data from Lunetta et al. 1997). The "upper Clearwater" includes the mainstem Clearwater from RM 18.5 to the headwaters, the Snahapish and Sollecks Rivers, Stequaleho Creek and other tributary streams. Riparian conditions in these reaches consisted of 69% rating "good", 19% rating "fair", and 11% rating "poor".

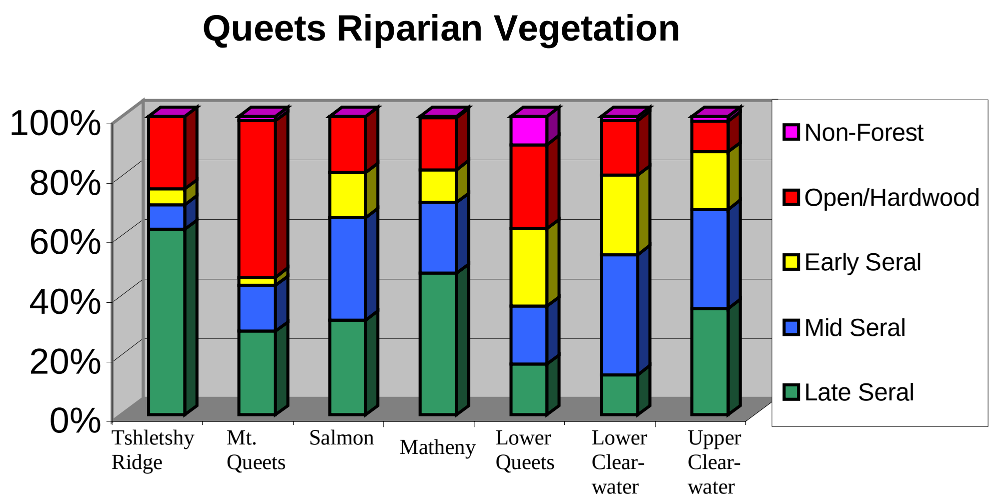
The percent pool habitat was assessed for several Clearwater River tributaries (Quinault Indian Nation, unpublished data 1990-1995). Streams that rate "poor" for percent pool habitat include Deception, Elkhorn, Manor, Peterson, Prairie, and Stequaleho Creeks (Quinault Indian Nation, unpublished data, 1990-1995). In addition, Snahapish River had segments that range from "poor" to "good". "Good" percent pool habitat was measured in Bull, Christmas, East Fork Miller, Hurst, Boulder (tributary to Hurst Creek), and Shale Creeks, and the West Fork Snahapish River. Hunt Creek percent pool habitat ranges from "fair" to "good", while segments of the Solleks River ranges from "poor" to "fair" for percent pool habitat (Quinault Indian Nation, unpublished data, 1990-1995).

Riparian Conditions in the Matheny Creek Sub-Basin

Generally riparian conditions have been impacted by timber harvest in the tributaries. The mainstem and larger tributaries (21.0176, 21.0180, Hook Branch Creek, and North Fork Matheny Creek) of the Matheny Creek sub-basin have significant amounts of old-growth riparian. These have been impacted to various degrees by windthrow, but still result in "fair" to "good" ratings for LWD recruitment (U.S. Forest Service 1995). Smaller tributaries (Type 4 and 5 streams) have been clearcut to the stream edge in the past, but now primarily support healthy conifer stands (R. McConnell, U.S. Forest Service, personal communication).

From RM 5.2 to 6.7 in Matheny Creek, the percent pool habitat was 56%, a "good" rating. In the tributaries, pool habitat was "poor" in Twin Peak (16%), Middle Fork (11%), and South Fork (10%) (U.S. Forest Service 1995).

Figure 8. Riparian vegetation conditions by WAU in the Queets Basin (data from Lunetta et al. 1997).



Water Quality Issues within the Queets Basin

Water Quality in the Mainstem Queets River

Water quality information for the Queets basin has been measured at several points in the lower river (Table 6). Information is available from the gauge in the Queets River near Clearwater (RM 4.5) (Alexander et al. 1998), from the Washington Department of Ecology monitoring site at Queets (R.M. 1.5), from Quinault Indian Nation monitoring at the Hartzel-Queets Valley Road on the Queets River, and at Picnic Bar on the Clearwater River (RM 0.5) (Alexander et al. 1998; Hallock and Ehinger 1995; G. Onwumere, Quinault Indian Nation, personal communication 2000).

In 1994, the Department of Ecology (DOE) monitoring at Queets showed good levels and saturation of dissolved oxygen, neutral pH, and fairly low water temperatures, although the July maximum of 16.7 ^{o}C is above the State water quality standard (Hallock & Ehinger 1995). The USGS monitoring showed winter water temperatures in the 4 - 5^{o}C range and summer water temperatures generally between 14 ^{o}C and 17^{o}C, with one 18.5^{o}C reading (Table 6). The warm water temperatures (>15.6^{o}C) result in a "poor" rating for water quality in the lower Queets River mainstem. Neutral pH readings and good levels of dissolved oxygen were also recorded (Alexander et al. 1998). Because these data are monthly samples, no information is available about the amount of time water temperatures are higher than the preferred range or the water quality standard. It is recognized that the low basin elevation and channel width may make it difficult or impossible to attain the DOE Class AA temperature standard.

Table 6. Summary of summer water temperature ranges and observed dissolved oxygen and pH levels in Queets River and tributaries.

Stream	Location	Summer water temperature range	Dissolved oxygen range	pH range
Queets River	Hartzel Boat Ramp[1]	10 - 17°C	8.9 - 12.5	7.1 - 7.6
Queets River	RM 1.5[3]	14.4 - 16.7°C	10.1 - 10.6	7.0 - 7.6
Queets River	RM 4.5 (approx.)[4]	11.0 - 18.5°C	8.2 - 10.9	6.9 - 8.2
Clearwater R	Picnic Bar RM (0.5)[1]	13 - 20.1°C	7.8 - 10.7	7.0 - 7.4
NF Matheny	RM 0.1[2]	7.4 - 15.1°C	9.4 - 11.0	
MF Matheny	RM 12.0[2]	12 - 15.4°C	9.0 - 9.6	
Hook Branch	RM 0.2 (approx.)[2]	10.1 - 15.6°C	9.3 - 10.3	
Matheny Cr.	RM 5.6[2]	12 - 17°C		
NF Salmon R.	RM 0.1[2]	10.1 - 15.2°C		
MF Salmon R.	RM 12.1[2]	9.0 - 15.8°C	9.5 - 11.1	
MF Salmon R.	N/A[1]	10 - 13.5°C	7.9 - 11.2	6.7 - 7.1
SF Salmon R.	RM 0.1[2]	10 - 14.6°C		
Salmon R. MS	RM 10.7[2]	12 - 16.5°C		
Salmon R. MS	RM 3.2[1]	11 - 15.9 °C	7.0 - 10.9	6.7 - 7.1
Sams River	RM 2.3[2]	12 - 17°C		
Sams River	RM 7.0[2]	10 - 14°C		
Sams River	RM 9.6[2]	10 - 13°C		

1. From periodic sampling, 1998 (G. Onwumere, Quinault Indian Nation, unpublished data, 2000).
2. From daily summary of continuous monitoring, 1999 (U.S. Forest Service, unpublished data, 2000).
3. From monthly sampling at Queets, 1994 (Hallock and Ehinger 1995).
4. From periodic sampling at USGS station 1204500, Queets River near Clearwater, 1978 - 1993 (Alexander et al. 1998).

Water Quality in the Sams River, Matheny Creek, and the Salmon River

Summer water temperatures for three long-term U.S. Forest Service monitoring sites (Sams River, Matheny Creek, and Salmon River) are presented in Table 7 (U.S. Forest Service, unpublished data 2001). Although there is some variation in sampling dates among sites and between years, this table generally summarizes measurements between July 1 and September 15. Maximum, mean, and minimum temperatures, as well as the number of days the maximum temperature reached or exceeded the state standard of 16^{o}C are presented. Warmer and cooler years were generally consistent at all three sites, with 1992, 1996, and 1998 generally characterized as the warmest years, and 1993 and 1999 as the coolest. Days over 16^{o}C varied between sites in 1995, although high temperatures were still similar to other warmer years. The number of days temperature exceeded the standard ranged from 14 to 59 in the Sams River, from 4 to 26 days in Matheny Creek, and from 0 to 24 days in the Salmon River.

Temperatures exceeding water quality standards have occurred in the lower Sams River with water temperatures exceeding 19^{o}C on several occasions (U.S. Forest Service 1997). No information about shading levels in the Sams River directly above the sampling point at RM 2.3 was found. However, the sampling site is apparently downstream of reaches identified in the watershed analysis as having degraded riparian areas that contribute to increased stream temperatures (U.S. Forest Service 1997). Degraded riparian areas and excess sedimentation are problems in the lower Sams River, and these impacts often lead to water quality problems through loss of shade and changes in width to depth ratios, but those parameters have not yet been analyzed and are an identified data need. The watershed analysis team labeled water temperature in lower Sams as "not properly functioning", and for this reason, the lower Sams River mainstem is rated "poor" and is also flagged as a data need for further resolution of this potential problem. The tributaries to lower Sams River are rated "good" based upon the watershed analysis statement that "Tributary temperatures are well within state temperature standards." (U.S. Forest Service 1997). The upper Sams River was found to have water temperatures within acceptable ranges (U.S. Forest Service 1997), and is rated "good" for water quality.

Summer water temperatures in lower Matheny Creek are warm (maximum temperatures ranged from 16.6 to 19.2^{o}C) (U.S. Forest Service 1995; U.S. Forest Service unpublished data), and this reach is rated "poor". Reduced shade and channel widening due to clear-cutting along lower Matheny are potential causes of the warmer water temperatures. While the lowest reach (RM 0-2.8) has naturally low shade, impacted reaches include the mainstem from RM 2.8-5.2 and tributaries 21.0180 and 21.0181 (U.S. Forest Service 1995). These two tributaries are rated "poor" for water quality. No measurements of shading levels in Matheny Creek directly above the sampling point at RM 5.6 was found, although the riparian vegetation immediately upstream of the monitoring site has been altered by past harvest and subsequent blow down (R. McConnell, U.S. Forest Service, personal communication 2001). Riparian areas upstream of RM 6.7 were rated “good” by the watershed analysis team (U.S. Forest Service 1995). The larger Matheny Creek tributaries (Hook Branch, North Fork, Middle Fork) have fairly cool summer water temperatures, and are rated "good".

The Salmon River watershed analysis team rated the Salmon River watershed “at risk” for temperature, and “properly functioning” for all other water quality parameters. Elevated water temperatures have been observed in the lower mainstem Salmon River downstream of RM 11. In the lower Salmon River (RM 3.2), water temperatures were above 16^{o}C for 49 days in 1997 and for 71 days in 1998 (G. Onwumere, Quinault Indian Nation, unpublished data, 2000). At RM 10.7, water temperatures exceeded 16^{o}C for 24 days in 1992 and 21 days in 1996 (Table 7) (U.S. Forest Service unpublished data). Canopy cover near the sampling point at RM 10.7 has not been quantified in the lower Salmon River sub-basin, but the stream channel upstream of the monitoring point is confined, and the riparian vegetation is fairly intact and does provide shading (R. McConnell, U.S. Forest Service, personal communication 2001). The low basin elevation and river width in the lower mainstem may make attainment of the 16^{o}C standard difficult. All maximum temperatures observed were below sub-lethal ranges.

While turbidity events were noted in the lower mainstem Salmon River, they are not common and apparently do not reflect a chronic problem. Dissolved oxygen levels and pH ranges were generally good in both the lower mainstem Salmon River and the tributary forks (Table 6). Turbidity, pH, and dissolved oxygen levels occasionally did not meet state standards; however, these problems are relatively minor (Onwumere 2000; U.S. Forest Service, unpublished data 2000).

In the South Fork Salmon River, water temperatures exceeded 16^{o}C seven times in 1995, twelve times in 1996, eight times in 1997, and six times in 1998. Turbidity, pH, and dissolved oxygen levels occasionally did not meet state standards (Quinault Indian Nation 2000). Because of the frequency of warm water temperatures, the mainstem Salmon River and the South Fork Salmon River are rated "poor" for water quality, with the note that further analysis is needed to determine the causes and appropriate standards for natural conditions.

In the Middle Fork and North Fork Salmon Rivers, some turbidity events have been noted (Quinault Indian Nation 2000), and water temperatures have ranged from 9.0 to 15.8 ^{o}C (Table 1). Generally, shading levels are good in the upper reaches of this sub-basin, with 80% of the North Fork, 79% of the South Fork, and 85% of the Middle Fork sub-basin riparian areas meeting target-shading levels (Lasorsa 2000). Due to the conflicting information of "good" shading and "fair" temperatures, these areas are not rated. No conclusions can be drawn about whether state water temperature standards can be naturally maintained at this elevation (480 feet).

Table 7. Temperature monitoring results in three Queets River tributaries (U.S. Forest Service, unpublished data 2001).

Sams River at RM 2.3				
Year	Maximum summer temperature ^{o}C	Mean summer temperature ^{o}C	Minimum summer temperature ^{o}C	Number of days $\geq$ 16^{o}C maximum
1992	19.3	15.3	11.3	59
1993	18.3	14.1	9.9	17
1994	18.8	14.4	10	37
1995	19.5	14.7	9.8	32
1996	19.4	15.1	10.7	54
1997	N/A			
1998	20	15.8	11.8	54
1999	17.2	12.2	7	14
Matheny Creek at RM 5.6				
Year	Maximum summer temperature ^{o}C	Mean summer temperature ^{o}C	Minimum summer temperature ^{o}C	Number of days $\geq$ 16 ^{o}C maximum
1992	18	13.9	8.6	9
1993	17	12.9	10.5	4
1994	16.7	13.2	9.8	4
1995	17.9	12.9	9.1	10
1996	18	13.8	10.1	18
1997	16.6	12.8	9.4	8
1998	19.2	14.2	10.9	26
1999	16.9	12.8	9.1	8
Salmon River at RM 10.7				
Year	Maximum summer temperature ^{o}C	Mean summer temperature ^{o}C	Minimum summer temperature ^{o}C	Number of days $\geq$ 16 ^{o}C
1992	17.7	13.7	10.2	24
1993	15.8	12.7	10.6	0
1994	15.3	12.8	9.9	0
1995	17.6	13.1	11.0	7
1996	17.4	13.5	10	21
1997	16.4	12.7	9.7	5
1998	17.5	13.7	10.9	19
1999	16.4	12.5	9.3	2

Water Quality in the Clearwater Sub-Basin

Summer water temperatures were found to be high in the lower Clearwater River (RM 0.5), with a maximum observed temperature of 20.1^{o}C from periodic sampling (Alexander et al. 1998). This results in "poor" rating for water quality, and is the highest summer water temperature recorded in the Queets Basin. While it has been noted above that the state standard may not always be attainable for larger rivers at low elevations, this temperature is close to the 21^{o}C temperature that is cited as one that could cause migration blockages for chinook salmon (see summary in Hicks 2000). No other temperature information was located for the Clearwater River and its tributaries. This is identified as a data gap. Both dissolved oxygen levels and the pH range were "good" in the lower Clearwater River (Alexander et al. 1998).

<u>Water Quantity Conditions in the Queets Basin</u>

This watershed has very high levels of precipitation (120"-200" annually) with some storms delivering up to 10" at a time (U.S. Forest Service 1997). Evaluation of available streamflow records (from the Queets, Clearwater and North Fork Quinault gages) did not lead the Matheny watershed analysis team to identify any clear trends in the number or magnitude of flow events over time or trends with increased intensity of timber harvest. They do estimate that in Matheny Creek, roads have increased the drainage density by as much as 16% but were unable to make any conclusions about the effects, if any, of drainage density or seral stage on peak flows. They noted that there was little overlap in time periods between the Clearwater and North Fork Quinault gauge records, which could explain why no trends were found (U.S. Forest Service 1995).

No conclusions were reached regarding possible trends in peak or low flow events in connection to timber harvest and road construction in the Salmon River sub-basin either (Bidlake 2000). The reason for this was primarily due to the short period of streamflow records on the Salmon River. The relative difference in timing of timber harvest between the lower Salmon River and the tributary streams was another possible factor mitigating against a definite conclusion (Bidlake 2000).

Both watershed analysis teams as well as other investigators (Sullivan et al. 1987) note that changes in flow events due to harvest practices often occur in conjunction with microclimate events (e.g. rain on snow or localized rainfall) and are likely to occur at a sub-watershed scale that may not be detectable by an analysis using flow records from a larger watershed (U.S. Forest Service 1995; Quinault Indian Nation 2000).

Land cover Vegetation in the Queets Basin

Several reports have listed more frequent and intensive flood events and scour as potentially major problems within the Queets Basin (U.S. Forest Service 1995; Bishop and Morgan 1996; Seiler memo 2000). Also, Seiler (2000) has demonstrated that higher flows during the coho salmon incubation period are correlated to lower smolt production in the Queets system. The widespread removal of trees is thought to increase storm run-off, thereby increasing peak flows in streams and increasing mortality of incubating salmon eggs (Rothacher 1963, 1965; Kovner 1957). Another contributing factor is the loss of LWD, which is needed to slow water velocities and to develop off-channel habitat. Excess sedimentation should also be examined as a potential impact to reduced access to off-channel refuge habitat during high flows.

Conditions of hydrologic maturity vary across the Queets Basin. The Queets River Basin upstream of the Sams River confluence is in a seral stage fairly consistent with historic conditions (i.e., affected by fires and windstorms). The Queets River within the Queets Corridor is also probably close to historic seral stage conditions, due to the fairly small impacts from homestead settlement prior to the establishment of the Queets Corridor in 1940 (Felt 1985). Seral stage conditions vary between the larger tributary sub-basins because the particular decade(s) of high harvest levels also varies between sub-basins and with ownership (see Historic Land Use section).

Large-scale (WAU) vegetative land cover age data is presented for the Queets watersheds in (Figure 9), and is used for rating watersheds where more precise data is not available. The Sams, Matheny, and Salmon sub-basins have more precise seral stage information from watershed analysis, and these data are used to rate land cover conditions instead of the coarse scale data.

Figure 9 compares the vegetative land cover age data from Lunetta et al. (1997) between the seven WAUs within the Queets Basin. Using this coarse level of data, three of the Queets Basin WAUs rate "poor" for hydrologic maturity (vegetation age): the lower Queets mainstem and smaller tributaries, the lower Clearwater River, and the upper Clearwater River. The two upper Queets WAUs (Tshletshy Ridge and Mount Queets) which lie mostly within the National Park, are rated "good" for water quantity.

Water Quantity Conditions in the Matheny Creek Sub-Basin

The Matheny Creek watershed analysis provided more specific data on hydrologic maturity, with finer tree stand age class information coupled with smaller geographic units (U.S. Forest Service 1995). Using our rating system with these data, most of the Matheny Creek sub-watersheds rate "poor" for hydrologic maturity (see the Assessment Chapter for details on our rating system). The "poor" rated areas include Lower Fork (44% immature), Twin Peak (73-82% immature), Hook Branch (49% immature), South Fork (61% immature), and Middle Fork (54% immature) sub-watersheds. Areas that rate "good" are the North Fork (28% immature) and upper Matheny (33% immature) watersheds. Given the current lack of timber harvest on U.S. Forest Service lands, this situation is expected to improve in the future.

There are no consumptive uses of significant amounts of water in this sub-basin (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

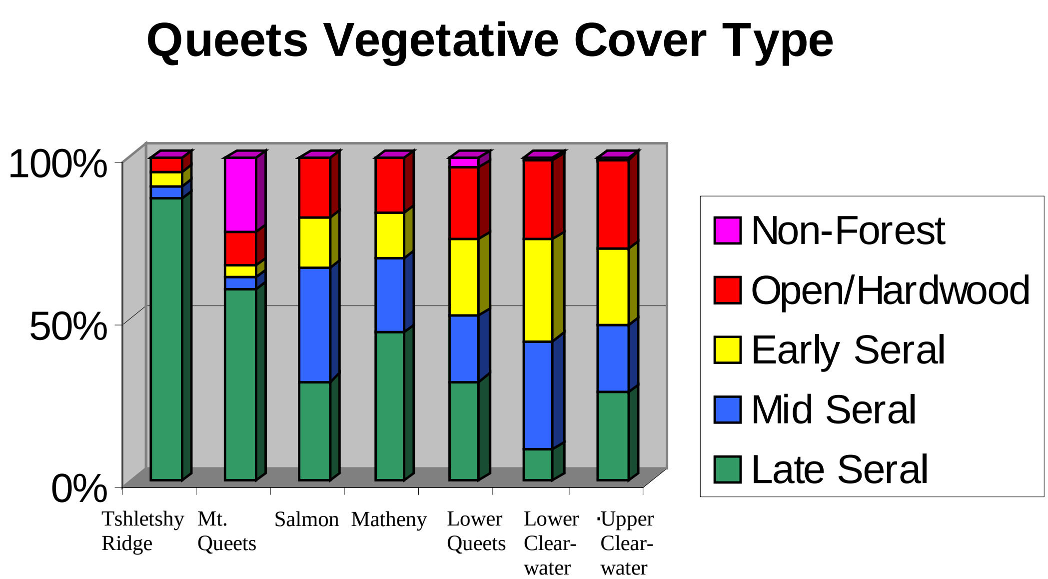
Water Quantity Conditions in the Sams and Salmon River Sub-Basins

While the mountainous areas along Sams and Matheny Ridges are in a late successional stage and located within the Olympic National Park, the lowlands have been converted from mature and old growth conifer to early and mid-seral stages (U.S. Forest Service 1997). Upper and lower Sams River still has a significant late seral stage component, 82% and 62% respectively, which results in a "good" rating. North Creek and Phelan Creek have less late seral stage lands (32% and 46% respectively) (U.S. Forest Service 1997). The greatest percentage of tree stage in North and Phelan Creeks is mid-seral, and most of that is mid-late seral. Therefore it is rated "good" using our criteria.

Within the Salmon River, land cover vegetation age is "good" for all sub-watersheds. In the North Fork, 16% of the land cover is hydrologically immature, while in the Middle Fork, South Fork, and lower Salmon River there is 20%, 15%, and 19% immature vegetation (data from Quinault Indian Nation 2000). In general, the southern side of the Salmon River watershed is more late successional, while the northern side is more early-mid successional. Alder is more common in the lower Salmon because of the extensive floodplain.

No information was found to suggest impacts from low flow conditions as a result of human actions. Because very little land is used for agriculture or urban purposes, water withdrawal impacts are expected to be low. The village of Queets has a water system that uses well water pumped from near the housing area in the village (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Figure 9. Vegetation age within the Queets Basin WAUs (data from Lunetta et al. 1997).



The Condition of Biological Processes in the Queets Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, which is likely a very conservative estimate of historic nutrient input. Most of the salmonid stocks within the Queets Basin are believed to be “healthy” (see Distribution and

Condition of Stocks section for more details). Coho salmon, fall chinook salmon, bull trout, winter steelhead and summer steelhead trout are listed as “healthy”, while spring/summer chinook returns are “depressed” (WDFW and WWTIT 1994). Because most of the stocks are considered “healthy”, biological processes are rated "good".

In addition, a benthic index of biological integrity was conducted in the Salmon River, and the index in that site rated "good" compared to indices in other areas throughout the Washington coast (Merritt et al. 1999). The U.S. Forest Service (Vinson 2000) conducted an inventory of aquatic macroinvertebrates in Matheny Creek and in the Salmon River. Their results indicate areas of "slight organic enrichment" in the mainstem Matheny Creek and the Salmon River. Reaches of "moderate organic enrichment" were noted for the Middle Fork Matheny Creek and Middle Fork Salmon River. A likely explanation for the "good" BIBI rating in the Salmon River is that the amount of adult coho salmon far exceeds other tributaries to the Queets River in terms of fish per mile (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). This is mainly a result of contributions from surplus hatchery coho to the spawning population. Adults access the entire Salmon River, providing good distribution of carcasses.

Habitat Limiting Factors in the Kalaloch Creek Basin

Loss of Fish Access in the Kalaloch Creek Basin

No information regarding fish access conditions was found for private lands in the Kalaloch Creek Basin. The SSHEAR database documented passage barriers at five culverts under Highway 101 within this drainage, but noted no habitat gain if fixed (“no gain” repair status) (WDFW 2000b). A full culvert inventory will be completed for Dept. Natural Resource (DNR) roads in the Kalaloch Creek Basin (K-series roads) by summer 2001. However, the fish passage criteria used by DNR assesses only upstream adult migration (B. Wikene, DNR, personal communication 2001). Due to the lack of current data, fish access conditions are not rated for the Kalaloch Creek Basin and are considered a data need.

Floodplain Conditions in the Kalaloch Basin

No information on floodplain conditions was found for this basin. Kalaloch Creek has a fairly confined channel due to topography, and inventories of channel conditions and floodplain impacts are a data need.

Streambed and Sediment Conditions in the Kalaloch Basin

No information on instream sediment conditions or hillslope sediment inputs was found for this basin. However, road density is high at 4.08 miles of road per square mile of watershed (Lunetta et al. 1997). This results in a "poor" rating for road density. As part of the DNR culvert assessment discussed above, sidecast road problems, culvert impacts, and slope failures will also be assessed. Sidecast removal projects for the K-series roads (on Kalaloch Ridge) are planned by WDNR, but not yet completed (B. Wikene, WDNR, personal communication 2001).

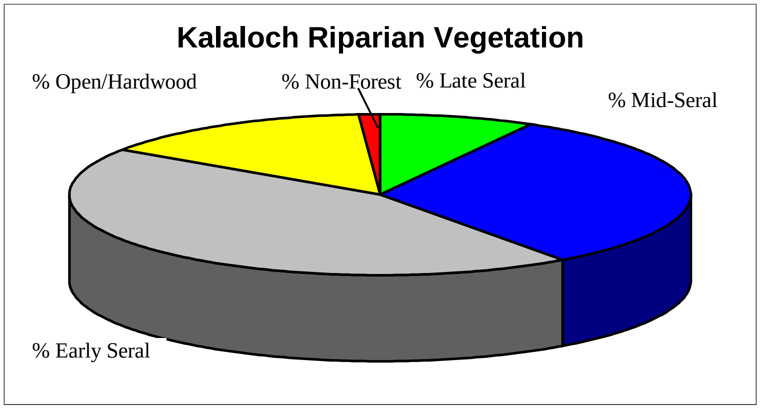
Data were lacking for instream estimates of LWD with the exception of a two-year comparison of LWD in one section of the mainstem Kalaloch Creek, just downstream of the West Fork Kalaloch Creek confluence (McHenry et al. 1998). The study compared old growth pieces (volume and number) and second growth pieces between 1982 and 1993. The volume and number of old growth LWD pieces decreased in that time period, while the volume and abundance of second growth pieces increased. The volume of old growth in 1982 was 53.72 cubic meters (in a 100 m reach) compared to 21.84 cubic meters in 1993 (McHenry et al. 1998). The number of old growth pieces dropped from 42 to 29 in that time period. The volume of second growth LWD increased from 1.41 cubic meters to 6.32 cubic meters from 1982 to 1993, and the number of pieces increased from 16 to 38. The riparian was logged in 1956, which removed remaining old growth conifer that would contribute to LWD.

Riparian Conditions in the Kalaloch Basin

Specific reach data for the riparian conditions in the Kalaloch Creek Basin are not available, but information on a WAU scale exists through the Lunetta et al. (1997) database. Using those data, approximately 15.5% of the WAU riparian response reaches rate "poor" because they are either open or comprised mostly of hardwoods. The extent of conversion to non-forest land (urban or agriculture) is very low at about 1%. Most of the WAU has "fair" riparian conditions, with 44.5% of the response reaches consisting of young conifer (Figure 10). About 39.9% of the reaches consist of "good" riparian buffers comprised of mid- to late seral stage forest.

The lower mile of the Kalaloch Creek mainstem and the nearby independent tributaries to the south of Kalaloch Creek have been part of Olympic National Park since 1940 (Felt 1985). Riparian conditions in those reaches are likely in good condition or at least improving from past land uses. However, National Park ownership accounts for only about 9.5% of the Kalaloch WAU. The remaining ownership includes 50.6% State-owned lands and 39.9 % private lands (Tony Hartrich, Quinault Indian Nation, unpublished data), and it is likely that the more impacted riparian reaches are in those areas.

Figure 10. Riparian vegetation in the Kalaloch WAU (data from Lunetta et al. 1997).



Water Quality Conditions in the Kalaloch Basin

The West Fork of Kalaloch Creek is on the 1998 303(d) List for water temperature (WA DOE 1998b), and was previously on the 1996 303(d) List. The listing stems from ten water temperature excursions measured between 7/1/92 and 3/31/92 (WA DOE 2000). The listing and the excursions result in a "poor" water quality rating for Kalaloch Creek with the note that more data are needed. The cause(s) of the warm water temperatures is not known. No other information on water quality for streams in this basin was found.

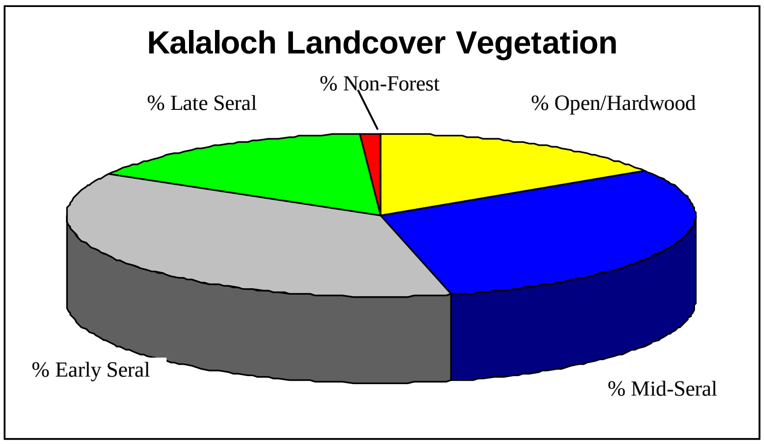
Water Quantity Conditions in the Kalaloch Basin

Potential flow impacts on salmonid habitat include human activities that change the natural flow pattern of a stream or worsen peak flows or low flows. Direct measurements of stream flow in the Kalaloch Basin are not available, and because of that, flow trends cannot be determined. However, some information regarding impacts to flows can be derived indirectly. In a conifer forest, 24%-35% of the precipitation is temporarily captured by the mature vegetation (Dingman 1994). The extensive removal of trees or change in age and type of trees can increase the magnitude of high flow events and route water more rapidly to channels. An increase in impermeable surfaces results in even greater impacts. Although there has not been significant development that would increase impermeable surfaces in the Kalaloch Basin, timber harvest has changed the landscape.

Seral stage information from a large scale (WAU) analysis shows that 15% of the Kalaloch Ridge WAU (which consists of the entire Kalaloch drainage) is classified as late seral, 30 % as mid-seral, 36 % as early seral, and an additional 15% hardwoods or open lands (Figure 11) (Lunetta et al. 1997). Very little (1%) of the landcover has been converted to non-forest uses, such as agriculture or urban lands. This results in 45%

relatively mature forest, and overall the Kalaloch WAU is rated "good" for hydrologic maturity. Also, most of the landcover consists of young conifer, which can provide a greater future hydrologic maturity.

Figure 11. Land cover vegetation type in the Kalaloch WAU (data from Lunetta et al. 1997).



Biological Processes in the Kalaloch Creek Basin

Biological processes include nutrient cycling, and our assessment of nutrient cycling is based upon trends in adult anadromous returns or achievement of escapement goals. Coho salmon and winter steelhead trout spawn and rear in the Kalaloch Creek Basin, but their status is unknown (WDFW and WWTIT 1994). Chum salmon were historically present in Kalaloch Creek, and current presence is unknown. Due to a lack of fish production data, biological processes are not rated and are considered a data gap.

Habitat Limiting Factors in the Raft River Basin

The Quinault Indian Nation will be conducting a watershed analysis of the Raft, North Fork Raft, and Red Creek sub-watersheds during 2001 with results available early in 2002. It is expected that more information regarding habitat conditions will be identified as part of that effort.

Loss of Fish Access in the Raft River Basin

Current fish habitat access conditions in the Raft River Basin are unknown. Between 1995 and 1997, 35 miles of tributary stream channels in the Raft River basin were manually cleared of cedar harvest waste (spaults) by crews of unemployed fishermen. The effects of this project and the potential for change in fish distribution in tributary streams have not yet been assessed (M. Mobbs, Quinault Indian Nation, personal communication 2001).

The SSHEAR database identified one culvert under Highway 101 at Crane Creek as a passage barrier with "repair required" status (WDFW 2000b). No other information regarding culverts and fish passage was located for this watershed. Due to the lack of data, fish access conditions are not rated and considered a data need.

Floodplain Conditions in the Raft River Basin

Current floodplain conditions in the Raft Basin are unknown. A "geologic floodplain" has been identified for the Raft River mainstem (M. Jones, USGS, draft information 2001), and current floodplain conditions will also be characterized as part of the watershed analysis. Recommendations from this new information will then be developed for the Raft River.

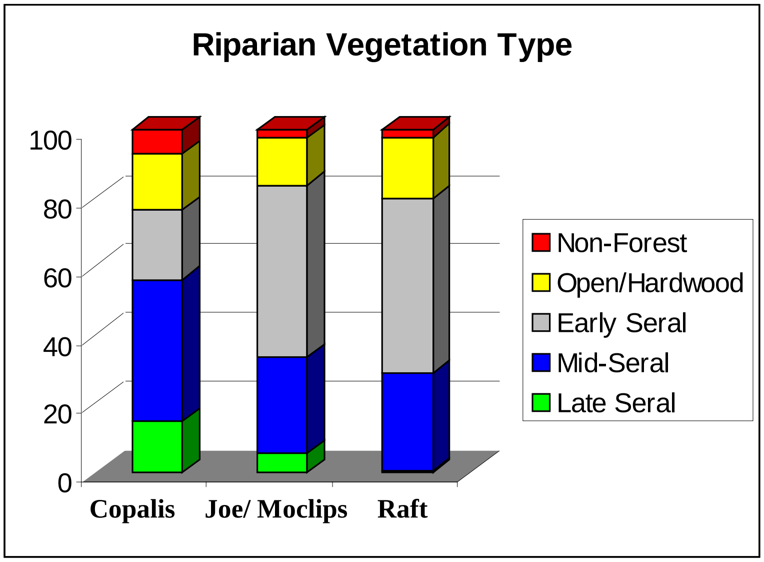
Streambed and Sediment Conditions in the Raft River Basin

Data are lacking for sediment sources, transport, and delivery within the Raft River Basin. Road densities are high in the Raft River WAU, estimated at 3.73 miles of road per square mile of watershed (Lunetta et al. 1997). Based on the assumption of a high rate of sediment delivery from roads, a "poor" rating for sedimentation is assigned with the note that more data are needed. No data were found for channel conditions or instream LWD levels.

Riparian Conditions in the Raft River Basin

No reach-specific riparian data were found for the Raft River Basin, but a coarse analysis on a WAU scale provides an overall level of impact. There is virtually no late-seral stage riparian remaining in the Raft River WAU, with a predominance of 51% early seral stage conifer and 28% mid-seral stage conifer (Figure 12) (data from Lunetta et al. 1997). The high young conifer component suggests that while near-term LWD recruitment potential is likely not good, the long-term recruitment is better. More analysis of this issue will be done as part of the Raft River watershed analysis. "Poor" riparian conditions comprised only 20% of the reaches, and included 18% open or hardwood and 2% conversion to non-forest lands (Figure 12) (Lunetta et al. 1997). Because most of the riparian reaches consist of young conifer, the overall riparian rating is "fair".

Figure 12. Riparian vegetation type within the Copalis, Joe/Moclips, and Raft River WAUs (data from Lunetta et al. 1997).



Water Quality Conditions in the Raft River Basin

Two sites in the Raft River Basin have been monitored by the Quinault Indian Nation from 1995 to the present (G. Onwumere, Quinault Indian Nation, unpublished data 2001). The sites are on the mainstem Raft River at the 4070 Road (approximately RM 5.5) and the North Fork Raft River at the West Boundary Road (approx. RM 13). Available data from 1995 through 1998, generally collected monthly, are summarized in Table 8.

Water temperatures at the West Boundary Road site were good, with recorded maximums of 13.6 to 14 ^{o}C. Temperatures were higher at the 4070 bridge, with recorded maximums of 13.7 to 18.1^{o}C. The highest temperature of 18.1^{o}C was recorded in July of 1995. It would appear that at least during some summers, water temperatures exceed state criteria and for this reason, water quality is rated "poor" for the Raft River. The influence of summer fog on water temperatures in this basin is not known, but may explain the fairly wide range of highest recorded temperatures between sampled years.

Dissolved oxygen levels at both sites were generally good, with some measurements falling into the "fair" range and a few into the "poor" (<6mg/l) range (Table 8). Turbidity levels at both sites were generally low. Because these data are from monthly or semi-monthly samples, the turbidity data are probably an indication of background levels and does not necessarily address the question of whether turbidity events, or turbidity problems, exist in the Raft River drainage.

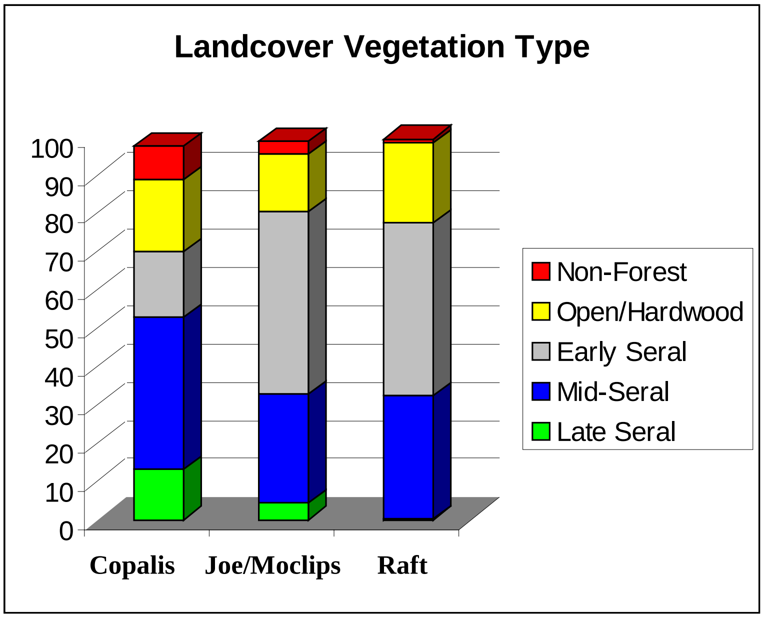
One interesting result was that the 4070 Bridge monitoring site had a fairly high range (4.7 to 8.1) of pH values. This range is outside of the WA DOE Class AA water quality standards (6.5 to 8.5) (WAC 173-201) and outside of the EPA standards for protection of aquatic life (6.5 to 9) (MacDonald et al. 1991). pH values are apparently not particularly sensitive to forest practices, although the introduction of bark and organic debris can influence pH in streams (MacDonald et al. 1991), as can inflows from wetlands (Mitsch and Gosselink 1986). The cause of the range of these pH values is not known and is identified as a data gap.

Water Quantity Conditions in the Raft River Basin

Direct measurements of stream flow in the Raft River Basin are not available, and because of that, flow trends cannot be determined. Stream flow in the Raft River was monitored from 1974 through 1980, but that is insufficient to assess trends and changes due to landcover alterations. However, some information regarding impacts to flows can be derived indirectly. In a conifer forest, 24%-35% of the precipitation is temporarily captured by the mature vegetation (Dingman 1994). The extensive removal of trees or change in age and type of trees can increase the magnitude of high flow events and route water more rapidly to channels. An increase in impermeable surfaces results in even greater impacts. In the Raft River drainage, there has not been significant development that would increase impermeable surfaces (conversions to non-forest land). However, timber harvest has changed the landscape.

Seral stage information from a large scale analysis shows that less than 1% of the Raft River WAU is estimated as late seral, 32 % as mid-seral, 45 % as early seral, and an additional 20% as hardwoods or cleared lands (Figure 13) (Lunetta et al. 1977). Only about 1.1% of the landcover is classified as non-forest (agriculture or urban lands). This indicates that at least 66% of the landcover is hydrologically immature. Because of this, water quantity is rated "poor" with a data gap identified for flow measurements.

Figure 13. Land cover vegetation in the Copalis, Joe/Moclips, and Raft WAUs (data from Lunetta et al. 1997).



Biological Processes in the Raft River Basin

Biological processes include marine-derived nutrient cycling. Due to a lack of more specific information on the levels of adult salmonid returns to adequately provide marine-derived nutrients, the attainment of adult escapement goals is our indirect measurement. It is recognized that escapement goals serve a fisheries management purpose and might be considered a low goal for marine-derived nutrients, but at this time, no other specific goals have been found. The Raft River provides habitat for coho salmon and winter steelhead trout, but the status of these stocks is "unknown". Without population trend data, the biological processes category is not rated and is considered a data need.

Habitat Limiting Factors in the Moclips River and Joe Creek Basins

Loss of Fish Access in the Moclips River and Joe Creek Basins

The SSHEAR database identified a total of eight culverts along SR 109 in Grays Harbor County (in the Moclips, Copalis, and lower Quinault drainages) that were barriers to salmonid habitat. Of these, six were assigned “repair required” status (WDFW 2000b) (Appendix 1). No other information regarding salmonid habitat access conditions in this basin was located.

In the past, a pond dam was located near the mouth of the Moclips River, which blocked access to about 90% of the stream to the anadromous salmonid runs. Its impact might have been large due its location near the mouth, the long time frame of existence, and the high percentage of stream blockage (Wendler and Deschamps 1955). The dam was eight feet high, likely built in the early 1900s, and laddered in 1940. The fish ladder was considered inadequate and was removed in the 1970s (Phinney et al. 1975).

A millpond has been noted in Beaver Creek, a tributary to Joe Creek (Phinney et al. 1975). It is not known whether it still exists and to what degree it might have impacted salmonids.

Floodplain Conditions in the Moclips River and Joe Creek Basins

No information was found about floodplain conditions in the Moclips River and Joe Creek, including information about the potential for roads and old railroad grades to affect streams and side channels. Past land use has resulted in a number of old railroad grades still present in the watershed or converted to roads (Capoeman 1990). This indicates that impacts exist, and identification and prioritization of these impacts are a data need.

Streambed and Sediment Conditions in the Moclips River and Joe Creek Basins

Little is known about sediment and instream conditions in either of these watersheds. In 1995 and 1996, 5.5 miles of Joe Creek had approximately 350 cords of cedar spaults removed from the active stream channel. Logjams were not removed. Coho were seen spawning in the upper reaches of Joe Creek subsequent to this project. Quality of spawning gravels in many reaches of Joe Creek is considered to be good (B. Erickson, Columbia Pacific RC&D, personal communication 2000).

On DNR lands in this basin (7% of the ownership) typical road and stream crossing concerns include old puncheon culverts and fills and abandoned railroad and road grades, which cause changes in stream and wetland flow patterns. During flooding, flood flows moving over old road and railroad fills could result in erosion and increased sediment delivery (A. Aschenbrenner, DNR, personal communication 2001). Given the past landuse history, it is likely that similar problems exist on private lands. Information about private lands remains a data gap.

In the Joe Creek drainage, the 6009-1 Road bridge over Joe Creek was identified as having a moderate potential for sediment delivery (sec. 16, T20N R11W). Also, a puncheon culvert failing with direct delivery to Joe Creek was identified in sec 22 (T20N R12W) (A. Aschenbrenner, DNR, personal communication 2001).

Overall road density data exists for the WAU that includes both Joe Creek and the Moclips River. Road density is "fair" at 2.56 miles of roads per square mile of watershed (data from Lunetta et al. 1997).

Riparian Conditions in the Moclips River and Joe Creek Basins

Information about riparian conditions in the Moclips River and Joe Creek was only available on a coarse level for the entire WAU that includes both the Moclips River and Joe Creek. These data indicate that the predominant riparian type is early seral forest (young conifer) at 47.4%, which is a "fair" riparian rating (Figure 12) (data from Lunetta et al. 1997). About 19% of the WAU consist of "poor" riparian and 33% is "good". Basin experts believe that due to past harvest practices, riparian canopy closure and makeup are not adequate to provide full riparian functions in Joe Creek (B. Erickson, Columbia Pacific RC&D, personal communication 2000).

Water Quality Conditions in the Moclips River and Joe Creek Basins

Joe Creek is on the 1998 DOE Section 303(d) List as having impaired water quality for dissolved oxygen and fecal coliform (WA DOE 1998b; Seiders 1995). The listing results in a "poor" rating for water quality. Also, the Pacific Beach wastewater treatment plant discharges to lower Joe Creek, where there is a stratified lagoon-like estuary with low dissolved oxygen levels (Jennings 1995).

One site on the North Fork Moclips River (approximately RM 0.5) and another on the mainstem Moclips River (approximately RM 6.0) have been monitored by the Quinault Indian Nation from 1995 to the present (G. Onwumere, Quinault Indian Nation, unpublished data 2001). Summaries of available data generally collected monthly from 1995 to 1998 are presented here for temperature, pH, dissolved oxygen, and turbidity (Table 8). Water temperatures ranged from 11.6 to 17.7^{o}C in the North Fork Moclips River and from 10.4^{o}C to 18.8 ^{o}C in the mainstem Moclips River. The highest recorded temperature was in July of 1998, so it would appear that at least during some summers, water temperatures exceed state criteria. This results in a "poor" water quality rating. The influence of summer fog on water temperatures in this basin is not known.

Dissolved oxygen levels at both sites were generally “good”, with some measurements falling into the "poor" and more commonly "fair" range. Turbidity levels were generally low. Since these data are from monthly or semi-monthly samples, this is probably an indication of background turbidity levels and does not necessarily address the question of whether turbidity events, or turbidity problems, exist in the basin.

One interesting result was that both of the Moclips monitoring sites had a fairly high range of pH values, from 4.3 to 7.2 in the North Fork and from 4.3 to 6.7 in the mainstem. These values are outside of the WA DOE water quality standards (6.5 to 8.5), and outside of the EPA standards for protection of aquatic life (6.5 to 9) (MacDonald et al. 1991). pH values are apparently not particularly sensitive to forest practices, although the introduction of bark and organic debris can influence pH in streams (MacDonald et al. 1991), as can inflows from wetlands (Mitsch and Gosselink 1986). The cause of the range of these pH values is not known, and is identified as a data gap.

Table 8. Quinault Indian Nation water quality monitoring summaries 1995 to 1998. (G. Onwumere, Quinault Indian Nation, unpublished data 2001).

Monitoring site	Water temperature range (^{o}C)	Dissolved oxygen range/ average (ppm)	pH range/ average	Turbidity range/Average (NTU)
Moclips River RM 6.0	10.4 - 18.8	6.0 - 10.7 / 8.7	4.3 - 6.7 / 5.5	0 - 7 / 1.2
North Fork Moclips River RM 0.5	11.6 - 17.8	5.9 - 9.7 / 8.1	4.3 - 7.3 / 5.7	0.0 - 3.7 / 0.95
Raft River RM 5.5 (4070 Bridge)	9.5 - 18.0	5.7 - 11.8 / 8.9	4.7 - 8.1 / 6.3	0 - 28 / 1.8
NF Raft River RM 13.0 (West Boundary Rd.)	8.2 - 14.1	7.1 - 12.7 / 9.9	6.2 - 7.5 / 6.8	0.3 - 20 / 1.6

Water Quantity Conditions in the Moclips River and Joe Creek Basins

Direct measurements of stream flow in the Joe Creek and Moclips River Basins are not available, and because of that, flow trends cannot be determined. Stream flow in the Moclips River was monitored from 1975 through 1981, but that is insufficient to assess trends and changes due to landcover alterations. However, some information regarding impacts to flows can be derived indirectly. In a conifer forest, 24%-35% of the precipitation is temporarily captured by the mature vegetation (Dingman 1994). The extensive removal of trees or change in age and type of trees can increase the magnitude of high flow events and route water more rapidly to channels. An increase in impermeable surfaces results in even greater impacts. Although there has not been significant development that would increase impermeable surfaces in the Moclips River and Joe Creek Basins, timber harvest has changed the landscape.

Seral stage information from a large scale analysis shows that 5% of the Joe/Moclips WAU is classified as late seral, 29 % as mid-seral, 47 % as early seral, and an additional 15% as hardwoods or cleared lands (Figure 13) (Lunetta et al. 1977). Only about 3.5% of the landcover is classified as non-forest (conversion to urban or agriculture). At least

66% of the landcover is hydrologically immature and is rated "poor" for water quantity. However, specific measurements of flow, relationship to human activities, and impacts to fish are needed.

Biological Processes in the Moclips River and Joe Creek Basins

Biological processes include marine-derived nutrient inputs, which are assessed by examining the level and trends of salmonid returns. However, historic data do not exist, and the level of adult returns needed for adequate nutrient cycling might be much greater than the goals used for fish management purposes. Two stocks of salmon and steelhead spawn in the Moclips River drainage, coho salmon and winter steelhead trout. The winter steelhead trout stock is considered to be "healthy", while the coho salmon stock has an "unknown" status. Without additional information regarding historic levels or nutrient cycling goals, the biological processes category is not rated and considered to be a data need.

Habitat Limiting Factors in the Copalis River and Connor Creek Basins

Loss of Fish Access in the Copalis River and Connor Creek Basins

The SSHEAR database identified a total of eight culverts along SR 109 in Grays Harbor County (in the Moclips, Copalis, and lower Quinault drainages) that were barriers to salmonid habitat. Of these, six were assigned “repair required” status (WDFW 2000b) (Appendix 1). Other than these culverts, no information about fish passage barriers was located for this basin. A data need exists to examine roads crossing streams and assess the presence and extent of blockages. In 1920, a pond dam was built in the lower mainstem of the Copalis River (Wendler and Deschamps 1955). The dam was 30 feet high and blocked approximately 70% of the stream. It was removed in 1920.

Floodplain Conditions in the Copalis River and Connor Creek Basins

Current information on floodplain conditions was not found for this basin. Because of the landuse history of railroad logging and the presence of road and railroad grades in the watershed, it is possible that impacts to the floodplain may be present (Capoeman 1990). In conjunction with a culvert survey, floodplain impacts should also be assessed and prioritized.

Connor Creek is an independent stream that is very important due to its complex nature of lakes, ponds, and wetlands, and coho salmon and the Olympic Mud Minnow (a State sensitive species) are known to use this stream. Landowners have manipulated the lower channel of the stream for years to straighten and shorten the path the stream takes across the beach to the ocean (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Although this activity has been curtailed in the last twenty years, the stream has taken an exaggerated path northward. If its course does not change, Connor Creek could become a tributary of the Copalis River.

The habitat in this lower reach of stream is not good. The channel is exposed with little to no vegetation along its sandy banks (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). The channel is shallow for most of its length with warm water temperatures and low flows. This results in a "poor" rating for floodplain conditions in Connor Creek.

Streambed and Sediment Conditions in the Copalis River Basin

Good quality spawning gravels are present in much of the Copalis River system (B. Erickson, Columbia Pacific RC&D, personal communication, 2000). However, it is considered likely that wood waste may also be a problem in stream channels in the Copalis River Basin, particularly the upper Copalis River (B. Erickson, Columbia-Pacific RC&D, personal communication 2000).

Overall road density is rated "fair" at 2.45 mile of roads per square mile of watershed (data from Lunetta et al. 1997). On DNR lands in this basin (5% of the ownership), typical road and stream crossing concerns include old puncheon culverts and fills and abandoned railroad and road grades, which cause changes in stream and wetland flow patterns. Flooding concerns on DNR lands include flood flows moving over old road and railroad fills causing erosion and sediment delivery (A. Aschenbrenner, WDNR, personal communication 2001). Because of the past timber management landuse history, it is likely that similar problems exist on private lands. Information about private lands remains a data gap.

In the Skunk Creek drainage old puncheon fills with the potential for failure are identified as a potential problem. In the Copalis River drainage, three puncheon culverts and two metal culverts are identified as having either failed or the potential to fail, causing blockages to fish passage (secs. 14-16, T19N R12W). Two culvert crossings in Nelson Creek are noted as having the potential for sediment delivery (secs. 14-16, T19N R12W) (A. Aschenbrenner, WDNR, personal communication 2001).

Riparian Conditions in the Copalis River Basin

Specific information about riparian conditions in the Copalis Basin was not found, but a coarse level analysis shows that the most common type (41%) of riparian vegetation consists of mid-seral forest (Figure 12). Together with late seral forest riparian (15%), this results in 56% rating "good" for riparian conditions (data from Lunetta et al. 1997). About 20% of the riparian reaches consist of young conifer, which rates "fair", and 16% includes hardwoods and open riparian ("poor"). An additional 7% rates "poor" due to conversion to urban or agriculture. Basin experts believe that due to past harvest practices, riparian canopy closure and makeup are not adequate to provide full riparian functions in the Copalis River (B. Erickson, Columbia Pacific RC&D, personal communication 2000). Also, the riparian vegetation has been removed along lower Connor Creek, and this reach is rated "poor" for riparian conditions (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

Water Quality Conditions in the Copalis River Basin

No information on water quality for streams in this basin was found. This is a data need.

Water Quantity Conditions in the Copalis River Basin

Direct measurements of stream flow in the Copalis River Basin are not available, and because of that, flow trends cannot be determined. However, some information regarding impacts to flows can be derived indirectly. In a conifer forest, 24%-35% of the precipitation is temporarily captured by the mature vegetation (Dingman 1994). The extensive removal of trees or change in age and type of trees can increase the magnitude of high flow events and route water more rapidly to channels. An increase in impermeable surfaces results in even greater impacts. In the Copalis River Basin, there has not been significant development that would significantly increase impermeable surfaces. However, timber harvest has changed the landscape.

Seral stage information from a coarse scale analysis shows that 13% of the Copalis River WAU is classified as late seral, 40 % as mid-seral, 17 % as early seral, and an additional 19% as hardwoods or cleared lands (Figure 13) (Lunetta et al. 1977). Only 9% of the landcover was converted to urban or agriculture. Because less than 60% (45%) of the landcover is hydrologically immature, water quantity conditions are tentatively rated "good", with a note that information is needed regarding stream flows and human impacts.

Biological Processes in the Copalis River Basin

Biological processes include marine-derived nutrient inputs, which are assessed by examining the level of anadromous salmonid returns. However, historic data do not exist for this basin, and the level of adult returns needed for adequate nutrient cycling might be much greater than the goals used for fish management purposes. Two stocks of salmon and steelhead spawn in the Copalis River drainage, coho salmon and winter steelhead trout, and both have an "unknown" status. Without adequate information, the biological processes category is not rated and considered to be a data need.

Estuary and Near Shore Conditions in WRIA 21

The coastal environment along WRIA 21 is a mix of linear beaches and steep cliffs (Schwartz et al. 1997). The sediment source for the beaches in this area is mostly from nearby rivers and sea cliff erosion, with some sediment from the Columbia River. The soft rocks result in many active sea cliff landslides. Between Copalis and Moclips are wide beaches with fine to medium grained sand (Figure 14). Other beaches along this WRIA are generally narrow with a wide variety of sand type, depending on the sediment from nearby sea cliffs (Figure 15) (Schwartz et al. 1997). The coastline from the north side of the Copalis estuary to the south side of Whale Creek is part of the Copalis Rock National Wildlife Sanctuary, designated in 1994. The Sanctuary extends offshore an average of 35 miles. The site is managed to protect its natural resources while encouraging compatible commercial and recreational uses (NOAA 2000). Tribal treaty rights are recognized in sanctuary management.

Compared to estuarine habitat within Puget Sound, naturally limited estuarine habitat exists at the mouths of the rivers in this WRIA, extending from the ocean to the upper extent of tidal influence. This makes the relative importance of estuarine habitat in WRIA 21 far more critical to local stocks. Estuarine habitat is critical for chinook salmon, and those that use the estuaries for a longer time period make up a greater proportion of adult returns in WRIA 21 (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). In years of high abundance, most chinook juveniles generally stay for only a short time in the Queets and Quinault estuaries (Chitwood and Bishop 1996a and 1996b). This might be due to density-dependent factors in a naturally limited estuarine habitat.

Impacts to the estuaries are generally minor compared to degradation of Puget Sound estuaries, and the overall condition of the estuaries is "good" with the exception of Joe Creek, which has some known problems that have not been fully assessed and is rated as a data gap. The Queets and Quinault estuaries have reduced levels of LWD compared to historic levels, limiting refuge habitat for salmonids (Chitwood and Bishop 1996a and 1996b). The lowest reaches of the Quinault River have been impacted by a low level of bank hardening and shoreline development, mostly on the south bank (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). Various attempts to protect the village of Taholah from ocean wave action have resulted in the construction of a seawall. Large rock continues to be added to the north end of the seawall, and this action is affecting the mouth of the Quinault River and the lowermost portion of the estuary (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication).

The mouth of the Queets River has changed over time, mostly due to erosion of the coastline (Rau 1973). For many years, the lower river traveled west, through the Queets village, and then turned north for almost a mile before draining to the ocean (Scott Chitwood, Jamestown S'Klallam Tribe, personal communication). In the mid-1980s, a large winter storm and high river flows caused the river to breach its banks and enter the ocean at the northerly turn. The old channel serves as a backwater area away from the main current and provides important estuarine habitat. In recent years, the river has gradually begun to regain its northward channel and is growing a larger estuary.

Attempts to control the meandering of Joe Creek have been made since at least 1939 (Workman 1997). Investigation of aerial orthophotos highlights that both sides of the Joe Creek estuary downstream of SR 109 have bank armoring to protect homes and the Pacific Beach State Park (Figure 16). However, the extent of impact for bank hardening and water quality problems in the Joe Creek estuary is not well-defined and is not rated.

Kelp is preferred by adult salmon (Levings 1985; Webb 1991), particularly by chinook and coho. While the north coast supports a large population of kelp, nearshore areas adjacent to this WRIA contains only a limited amount of giant kelp (*Macrocystis integrifolia*) located in the region from Destruction Island to Brown's Point. From 1996 to 1997, the coverage area of this kelp declined by 29% (Van Wagenen 1998). The cause of the decline is unknown, and additional monitoring is recommended to determine if this is within a natural range or part of a declining trend.

Figure 14. Wide beach stretch near the Moclips River (photo from DOE 2001b).

Figure 15. Sea cliffs near the Quinault River mouth (photo from DOE 2001b).

Figure 16. Bank Hardening along Mouth of Joe Creek (photo from WA DOE 2001b).

Known Salmonid Habitat Blocking Culverts in WRIA 21.

The Salmon Screening, Habitat Enhancement, and Restoration Division database (WDFW 2000b) has information on a total of 63 culverts in WRIA 21. Roads surveyed include the North and South Shore Roads at Lake Quinault, Highway 101, and State Route 109. In addition, one entry for the H-C Mainline Road and one for the C-1100 Road in the Clearwater River basin was found. They are summarized by sub-basin, below. No other information regarding culverts or fish passage barriers elsewhere in WRIA 21 was found, except for Cook Creek, which is summarized below.

<u>Quinault River downstream of Lake Quinault:</u>

WDFW Site ID	Stream Name	Tributary to:	Repair Status	Road Name	T/S/R
990276	McCalla Creek	Quinault River	Requires repair	US 101 (123.05)	7/22N/09W
991269	McCalla Creek	Quinault River	Unknown	US 101 (123.0)	22N/09W

(WDFW 2000).

<u>Cook Creek</u>

Anadromous fish passage upstream of RM 4.5 in Cook Creek is blocked by the Quinault National Fish Hatchery weir, which started operations in 1968. This limits anadromous production in the Cook Creek sub-basin to the lower 4.5 miles of Cook Creek and Chow Chow, Elk, and Red Creeks. The weir prevents migration into Hathaway and Skunk Creeks (Mobbs 1999a).

<u>Lake Quinault Sub-Basin</u>

WDFW Site ID	Stream Name	Tributary to:	Repair Status	Road Name	T/S/R
21.0460 0.10	Higley Creek	Lake Quinault	Requires repair	N Shore Rd	13/23N/10 W
21.0463 0.10	McCormick Creek	Lake Quinault	Requires repair	N Shore Rd	18/23N/09 W
21.0464 0.10	Slide Creek	Lake Quinault	Requires repair	N Shore Rd	18/23N/09 W

(WDFW 2000)

Independent Pacific Ocean tributaries within WRIA 21

WDFW Site ID	Stream Name	Tributary to:	Repair Status	Road Name (milepost)	T/S/R
Jefferson County					
990549	Unnamed	Pacific Ocean	No gain	US 101 (154.5)	24N/12W
990722	Unnamed	Pacific Ocean	No gain	US 101 (154.85)	28/23N/13W
990723	Unnamed	Pacific Ocean	No gain	US 101 (155.2)	9/24N/13W
990725	Unnamed	Pacific Ocean	No gain	US 101 (159.05)	4/23N/13W
990726	Unnamed	Pacific Ocean	No gain	US 101 (159.2)	33/25N/13W
990727	Unnamed	Pacific Ocean	No gain	US 101 (159.65)	33/25N/13W
991267	Unnamed	Pacific Ocean	No gain	US 101 (155.35)	15/24N/13W
991268	Unnamed	Pacific Ocean	No gain	US 101 (153.8)	27/24N/13W
991276	Unnamed	Pacific Ocean	No gain	US 101 (156.1)	15/24N/13W
Grays Harbor County					
990922	Unnamed	Pacific Ocean	Requires repair	SR 109 (35.6)	24/21N/12W
990927	Unnamed	Pacific Ocean	Unknown	SR 109 (39.2)	1/21N/13W
991265	Unnamed	Pacific Ocean	Requires repair	SR 109 (26.1)	32/20N/12W
991266	Unnamed	Pacific Ocean	Requires repair	SR 109 (33.4)	21N/12W

WDFW Site ID	Stream Name	Tributary to:	Repair Status	Road Name (milepost)	T/S/R
991270	Unnamed	Pacific Ocean	Fixed	SR 109 (36.4)	19/21N/12W
991271	Unnamed	Pacific Ocean	Requires repair	SR 109 (36.3)	21N/12W
991272	Unnamed	Pacific Ocean	Requires repair	SR 109 (33.1)	6/20N/12W
991278	Unnamed	Pacific Ocean	Requires repair	SR 109 (26.11)	14N/10W

(WDFW 2000)

Other Sub-Basins within WRIA 21

WDFW Site ID	Stream Name	Tributary to:	Repair Status	Road Name (milepost)	T/S/R
Clearwater River					
21.0024 0.05	Donkey Creek	Clearwater River	Requires repair	H-C Mainline	29/24N/12W
21.0042 0.0	Iska Creek	Clearwater River	Requires repair	C-1100 Road	
Queets River					
21.0160 A 0.1	Unnamed	Tacoma Creek	Requires repair	FR 3300/3350	4/24N/11W
990178	Harlow Creek	Queets River	Fixed w/fishway	US 101 (146.85)	32/24N/12W
Raft River					
990833	Crane Creek	Raft River	Requires repair	US 101 (137.35)	16/23N/11W

(WDFW 2000)

ASSESSMENT OF HABITAT LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496 and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. To provide the best guidance possible, current, known habitat conditions were identified and rated. Rating habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

To develop a set of standards that rate salmonid habitat conditions, several tribal, state, and federal documents using habitat rating systems (Table 9) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: “good”, “fair”, and “poor”. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The ratings adopted by the WCC are presented in Tables 10-11. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgement of the TAG should be used to assign the appropriate ratings. In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures used are clearly documented in the limiting factors report.

A summary of the habitat conditions for WRIA 21 is presented in Table 12. These represent generalized conditions within that stream. There are likely some reaches of the stream that will be better or worse condition than the rating suggests. In many cases, insufficient data and knowledge about the conditions was found. For those instances, the rating is left blank. The conditions are based upon the standards in Tables 10-11, and are described in more detail in the Habitat Limiting Factors Chapter. In the following chapter, recommendations and data needs are described in more detail.

Table 9. Source documents for the development of standards

Code	Document	Organization
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
NMFS	Coastal Salmon Conservation: Working Guidance (1996)	National Marine Fisheries Service
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan (1999)	Point No Point Treaty Council and Washington Department of Fish and Wildlife

Table 10. Salmonid habitat condition standards.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m)	Diameter (m)	Length (m)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50’ 26 4.1 75’ 23 3.1 100’ 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/ WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	• <75' or <50% of site potential tree height (whichever is greater) OR • Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC
Lakes (further work needed)						
Estuaries – See Table 3 Below						

Table 11. System for rating estuarine habitat conditions.

Rating of Estuarine Habitat Conditions									
All Values are Referenced to Historic Conditions of Estuary which is defined as both wetted and upland area.									
The following system can be applied for both large and small estuaries.									
Large Estuaries are defined as an estuary where the area of Zone 1 and 2 combined is greater than approximately 2.0 sq miles									
For large estuaries, treat zone 1, 2 and 3 seperately. For small estuaries, treat zone 1 and 2 as one area combined.									
	Zone Characteristics	Parameter	Poor		Fair		Good		
Upper	FW tidal to brackish marsh area.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Carex.	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	Ranges down to where Fucus and	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	Salnicornia become prevelant and	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.
	Carex is sparse.								
		Aquatic Conditions							
		1- % Historic Marsh Remaining	< 25%	2	25-50%	6	> 50%	10	Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2	25-50%	6	< 25%	10	Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2	25-50%	6	< 25%	10	Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2	25-50%	6	< 25%	10	Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2	10-25%	6	< 10%	10	Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)							
		Only one score depending on whether there has	> 50%	2	10-50%	6	<10%	10	% Reduction in Average Annual Flow
		been a net increase or decrease			OR				
			> 50%	2	10-50%	6	<10%	10	% Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns	Large	2	Medium	6	High	10	Subjective rating
		8- Water quality (Subjective)	Poor	2	Fair	6	Good	10	Subjective rating
		Overall Zone Rating							
		Good	73-100						
		Fair	48-72						
		Poor	20-47						
Lower	Brackish Marsh to delta face.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Fucus	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	and Salnicornia. Zone stops along	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	shore where these marsh plant stops.	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.

		Aquatic Conditions				
		1- % Historic Marsh Remaining	< 25%	2 25-50%	6 > 50%	10 Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2 25-50%	6 < 25%	10 Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2 25-50%	6 < 25%	10 Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2 25-50%	6 < 25%	10 Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2 10-25%	6 < 10%	10 Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)				
		Only one score depending on whether there has been a net increase or decrease	> 50%	2 10-50%	6 < 10%	10 % Reduction in Average Annual Flow
				OR		
			> 50%	2 10-50%	6 < 10%	10 % Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns)	Large	2 Medium	6 High	10 Subjective rating
		8- Water quality (Subjective)	Poor	2 Fair	6 Good	10 Subjective rating
		Overall Zone Rating				
		Good	73-100			
		Fair	48-72			
		Poor	20-47			
Nearshore Marine	Zone bounded by the edge of the delta to the boundary of the photic zone and continuing along the shore to a point halfway to the next estuary.	% Diked or Bulkheaded	> 66%	2 33-66%	6 < 33%	10
		Docks/km of Shoreline	> 10	1 4 to 9	3 < 4	5
		% Intact Riparian Zone	< 25%	1 25-50%	3 > 50%	5 Defined as within 100 ft of MLLW
		% Covered by Exotic Aquatic Plants	> 25%	1 10-25%	3 < 10%	5
		Overall Zone Rating				
		Good	19 to 25			
		Fair	12 to 18			
		Poor	5 to 11			

	Small	Large	
Overall Estuary Rating			In small estuaries zones 1 and 2 are combined into a single score.
Good	**92-125**	**164 to 225**	
Fair	**60-91**	**107 to 163**	
Poor	**25-59**	**65 to 106**	

Notes:
See Summer Chum Report from Hood Canal
Consider this a first order approximation
Vegetation zones will need to be more precisely defined but they should be more or less delineated in a field day.
All area calculations should be based upon the historically defined estuarine area and its associated floodplain.
Reveted and levees may be correlated with mainstem and off channel habitat lost.
One problem is that this is weighed heavily in favor of the marsh part of the estuary. The nearshore is diminished in importance. Will need to weigh this somehow.

Table 12. Summary of WRIA 21 Limiting Factors Results

	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Current Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Quinault Basin										Fair
Quinault Estuary		Good (DG)				Fair (DG)		DG		
Lower Quinault Sub-Basin	DG	Fair (DG)	Fair (DG)	DG	DG		Fair-Good along ms	Good in ms	Poor	
O'Took Creek	DG	DG	DG	DG	DG	DG	Poor	Fair-Good		
Joe Creek	DG	DG	DG	DG	DG	DG	Fair	Poor		
Mounts Cr.	DG	DG	DG	DG	DG	Fair-Good	Poor	Poor		
Ten O'clock Creek	DG	DG	DG	DG	DG	Fair-Good	Fair	Poor-Good		
Camp Creek	DG	DG	DG	DG	DG	Fair-Good	Fair	Fair		
Canyon Cr.	DG	DG	DG	DG	DG	Fair-Good	Fair	Fair-Good		

	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Current Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
North Boulder Cr.	DG	DG	DG	DG	DG	DG	Fair-Poor	Poor-Good		
South Boulder Cr.	DG	DG	DG	DG	DG	DG		Fair-Good		
Railroad Cr.	DG	DG	DG	DG	DG	Fair-Good	Fair	Poor		
Prairie Cr.	DG	DG	DG	DG	DG	Fair-Good	Fair	Poor		
Cook and Elk Creeks	DG	DG	Fair (DG)	DG	DG	Poor (DG)	Poor in Elk; Fair-Good in Cook	Poor in lower Cook; Good in Elk and upper Cook	Poor	
Lake Quinault WAU	DG	Poor along mainstem	DG	DG	DG (Concern about scour)	DG	Poor along mainstem	Poor in main-stem	Good (DG)	
Finley Creek	DG	Poor	DG	DG	DG	DG	Poor in lower; Good in upper	DG		

	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Current Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Kestner Cr.	DG	Poor	DG	DG	DG	DG	Poor in lower; Good in upper	DG		
Big Creek	DG	DG	DG	DG	Poor	DG	Fair in lower; Good in upper	DG		
Inner Creek	DG	DG	DG	DG	Poor	DG		DG		
Zeigler Cr.	DG	DG	Poor in lower; Good in upper.	DG	Poor in lower; Good in upper.	Poor in lower; Good in upper.	Poor in lower; Good in upper	DG		
Lake Quinault			DG, Concern					Good	DG	Poor
Enchanted Valley WAU	Good (DG)	Poor in lower (DG)	Good (DG)	DG	DG	DG	Good	Good	Good	
Mt. Lawson WAU	Good (DG)	Poor in lower (DG)	Good (DG)	DG	DG	DG	Good	Good	Good	

	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Current Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Queets Basin										Good
Upper Queets	Good	Good	Good							
Sams River	Good	Poor	Poor	Good	Fair-Poor	Poor	Poor in response reaches; Fair-Good in transport reaches.	Poor in lower; Good in upper.	Good	
Queets Corridor WAU		Poor (DG)	Fair (DG)				Good (DG)	Poor in lower		
Matheny Creek	DG (concern about debris flow blocks)	DG (concern for sediment and lack of LWD on off-channel habitat.	Poor	Poor in lower mainstem.	Poor in lower.	Poor in lower mainstem.	Fair to Good	Poor in lower; Good in upper.	Poor except in NF and upper Matheny, which are Good	

	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Current Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Salmon River	Good	Good (DG)	Poor	Good except in upper South Fork and Middle Fork		Poor in the South Fork and lower Salmon River (DG)	Fair to Good	Poor in main-stem and SF.	Good	
Clearwater Sub-basin	DG (high road density)	DG (concern re: off-channel habitat)	Poor (DG)	DG (Poor in past)	DG	DG	Mixed, mostly Fair in Lower; Mostly Good in upper.	Poor in lower. DG for other areas.	Poor (DG)	
Lower Queets	DG	Good (DG)	Fair (DG)						Poor (DG)	
WRIA 21 Estuaries		Good, except Joe Creek-DG.						Good (DG); Joe DG		
Kalaloch	DG	DG	Poor (DG)	DG	DG	DG	Fair (DG)	Poor (DG)	Good (DG)	DG

	Fish Passage	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Current Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
Raft	DG	DG	Poor (DG)	DG	DG	DG	Fair (DG)	Poor	Poor (DG)	DG
Moclips River and Joe Creek	DG	DG	Fair (DG)	Good (DG) in Joe Creek; DG others	DG	DG	Fair (DG)	Poor	Poor (DG)	DG
Copalis	DG	DG	Fair (DG)	Good (DG)	DG	DG	Good (DG)	DG	Good (DG)	DG
Connor Creek	DG	Poor in lower	Fair (DG)	DG	DG	DG	Poor in lower (DG)	DG, likely poor	DG	DG

DG= Data Gap

RECOMMENDATIONS AND DATA NEEDS FOR WRIA 21 HABITAT LIMITING FACTORS

Recommendations for Salmonid Habitat Restoration Actions in the Quinault Basin

Based upon limited available data, the known, current salmon and steelhead habitat conditions for the Quinault Basin have been identified and assessed as "good", "fair", or "poor". In addition, the impacts, sources of impact, and species impacted have been described whenever possible in the Habitat Limiting Factors Chapter, although detailed habitat data were generally lacking. Some of the major factors have also been mapped to show the extent of the conditions. Based upon this assessment, the following general recommendations for habitat improvements and protection are listed by type of factor. High priority recommendations are designated with a red diamond. As more detailed habitat assessments occur, priorities may change, new issues may be prioritized, and recommendations should become more specific.

<u>Access</u>

- Barriers to anadromous salmonids should be addressed, and solutions should include the transport of LWD and sediments, as well as fish access.

- High priority will be given to access projects that either open up significant quantities of habitat (percent useable reach), open good quality habitat, benefit multiple stocks of salmonids, or benefit a stock at risk.

<u>Floodplains</u>

- Seek alternatives to bank armoring, particularly along North Shore Road, South Shore Road, and Graves Creek Road.

- Reduce riparian roads and consider alternative sites when a riparian road washes out. Consideration should be given to moving the roads in the upper Quinault to the extreme edges of the valley, above the floodplain.

<u>Sediment</u>

- Address potential sediment sources from roads, especially roads with large fills or undersized culverts (those that do not meet 100 year flows plus debris).

- Address other road sediment problems, including specific road decommissioning, stabilization, and improvements. This also includes removal of sidecast material.

- Limit inappropriate removal of instream LWD.

Riparian

- Hardwood riparian areas that were historically conifer should be managed in a manner to encourage establishment of a conifer-dominated riparian forest. Silvicultural practices to enhance the growth of existing conifer trees and/or re-introduce conifer trees should be practiced where appropriate through the planting and release of shade-tolerant trees with a goal to increase the size, abundance, and distribution of large conifers.

- Funds, lands, and easement opportunities should be identified to purchase areas of mid- to late seral (and older) stage riparian for conservation and protection, with higher priority given to older stands.

- Riparian surrounding wetlands should be protected to insure ground water recharge.

- Decrease and prevent the introduction of non-native plant species.

Water Quality

- Prioritize riparian restoration in open riparian areas of temperature-impaired streams.

Water Quantity

- Maintain sufficient hydrologic maturity to limit the contribution of land management practices to increased peak flows and decreased hydrologic lag times.

- Decrease artificial drainage (roads) to streams in the Quinault Basin.

Biological Processes

- Develop a habitat restoration strategy for Lake Quinault that identifies critical limiting factors, prescribes remedial actions, evaluates anticipated outcomes, and defines an implementation strategy.

Recommendations for Salmonid Habitat Restoration Actions in the Queets Basin

The known, current salmon and steelhead habitat conditions for the Queets Basin have been identified and assessed as “good”, “fair”, or “poor”. In addition, the impacts, sources of impact, and species impacted have been described whenever possible in the Habitat Limiting Factors Chapter. Some of the major factors have also been mapped to show the extent of the conditions. Based upon this assessment, the following recommendations for habitat improvements and protection are listed by type of factor. High priority recommendations are marked with a red diamond. As assessments occur, priorities may change and new issues may be prioritized.

Access

- Barriers to anadromous salmonids should be addressed, and solutions should include the transport of LWD and sediments, as well as fish access.

- High priority will be given to access projects that either open up significant quantities of habitat (percent useable reach), open good quality habitat, benefit multiple stocks of salmonids, or benefit a stock at risk.

- Inventory and remove spaults from streams and floodplains. This will also aid riparian and water quality conditions.

Floodplain

- Maintain natural conditions in the delineated geologic floodplain in the Salmon and Queets Rivers. Protect floodplain habitat in other streams.

- Maintain existing functional off-channel habitat, particularly in the Clearwater River, lower Queets River, Sams River, lower Salmon, and Matheny Creek.

- Restore lost or degraded off-channel habitat in the above areas.

Streambed/Sediment

- Address potential sediment sources from roads, especially roads with large fills or undersized culverts (those that do not meet 100 year flows plus debris).

- Address other road sediment problems, including specific road decommissioning, stabilization, and improvements. This also includes removal of sidecast material.

- Limit inappropriate removal of instream LWD.

- Increase channel complexity. Utilize instream structures as an interim part of a broader restoration plan in appropriate areas.

Riparian

- Hardwood riparian areas that were historically conifer should be managed to allow conifer introduction through the planting and release of shade-tolerant trees with a goal to increase the size, abundance, and distribution of large conifers.

- Funds, lands, and easement opportunities should be identified to purchase areas of mid- to late seral (and older) stage riparian for conservation and protection, with higher priority given to older stands.

- Riparian surrounding wetlands should be protected to insure ground water recharge.

- Decrease and prevent the introduction of non-native plant species.

Water Quality

- Prioritize riparian restoration in open riparian areas of temperature-impaired streams.

Water Quantity

- Maintain sufficient hydrologic maturity to limit the contribution of land management practices to increased peak flows and decreased hydrologic lag times.

- Decrease artificial drainage (roads) to streams in the Queets Basin.

Recommendations for Salmonid Habitat Restoration Actions in the Kalaloch, Raft, Moclips, Joe, Copalis, and other Small Coastal Watersheds

Access

- Barriers to anadromous salmonids should be addressed, and solutions should include the transport of LWD and sediments, as well as fish access.

- High priority will be given to access projects that either open up significant quantities of habitat (percent useable reach), open good quality habitat, benefit multiple stocks of salmonids, or benefit a stock at risk.

Floodplain

- Maintain natural conditions in the floodplains and restore disconnected off-channel habitat.

Sediment

- Address potential sediment sources from roads, especially roads with large fills or undersized culverts (those that do not meet 100 year flows plus debris).

- Address other road sediment problems, including specific road decommissioning, stabilization, and improvements. This also includes removal of sidecast material.

- Limit inappropriate removal of instream LWD.

- Increase channel complexity. Utilize instream structures as an interim part of a broader restoration plan in appropriate areas.

Riparian

- Hardwood riparian areas that were historically conifer should be managed to allow conifer introduction through the planting and release of shade-tolerant trees with a goal to increase the size, abundance, and distribution of large conifers.

- Funds, lands, and easement opportunities should be identified to purchase areas of mid- to late seral (and older) stage riparian for conservation and protection, with higher priority given to older stands.

- Riparian surrounding wetlands should be protected to insure ground water recharge.

- Decrease and prevent the introduction of non-native plant species.

Water Quality

- Prioritize riparian restoration in open riparian areas of temperature-impaired streams.

Water Quantity

- Maintain sufficient hydrologic maturity to limit the contribution of land management practices to increased peak flows and decreased hydrologic lag times.

- Decrease artificial drainage (roads) to streams.

Recommendations for Salmonid Habitat Restoration Actions in WRIA 21 Estuaries and Near Shore Habitat

- Evaluate alternative strategies to increase stable large woody debris (LWD) in the Quinault and Queets estuaries.

- Protect the natural state of the lower river reaches by preventing bank armoring along the lower reaches of the streams and along the estuaries.

- WRIA 21 estuarine habitat is not as impacted as in other areas of Washington State. Currently good estuary habitat should be protected against additional dredging, filling, contaminants, and other impacts.

Data Needs for Salmonid Habitat Assessments in the Quinault Basin

This report was limited in its ability to clarify and prioritize impacts because of key data gaps. The following is a list of data needs that have been identified by the TAG. These data would greatly aid in developing effective recovery plans and to monitor the effectiveness of salmon habitat projects. The studies will also help better identify habitat limiting factors for salmonid production in the future. The TAG designated data needs associated with a red diamond as "high priority".

Fish

- The distributions of anadromous and resident fishes throughout the basin should be documented to characterize habitat uses by season and life history stages to support habitat limiting factor analyses and to support identification of production and/or survival bottlenecks.

Access

- Inventory, assess, and prioritize blockages to salmonid habitat in the Quinault Basin. Coordinate prioritization between agencies and ownerships. Prioritize culvert identification and assessment in the lower Quinault sub-basin.

- Assess and prioritize impacts from old railroad and road grades in the lower Quinault sub-basin.

Floodplains

- Survey and map all revetment work.

- Investigate whether remote sensing can produce a more accurate map of wetland habitats.

Streambed Sediment

- Monitor scour in the mainstem Quinault River from the Lake upstream to the confluence with Graves Creek and in the lower North Fork Quinault River, prioritizing known important spawning areas.

- Perform a geomorphic survey and analysis of the basin upstream of Lake Quinault to characterize prime factors causing the present river channel and floodplain instability and to place present conditions into a historical perspective (i.e., are the present conditions part of a trend, cycle, or the result of episodes). Develop information to support long-term road planning and fisheries management in the Lake Quinault sub-basin.

- Develop a new digital elevation model for WRIA 21 with a minimum of 10 meter resolution size to better reflect current conditions (presently, elevations are based on 50 year old data).

- Assess instream LWD in the lower Quinault, as well as future LWD recruitment potential.

Riparian

- Riparian conditions (vegetation type, age, size) should be analyzed for the land upstream of Lake Quinault.

- Comprehensive habitat surveys are needed throughout the large channels and tributaries upstream of Lake Quinault. These should include assessment of LWD, pools, riparian, and gravels.

Water Quality

- Investigate water quality conditions and causes in the Quinault Basin.

- Monitor water temperature in the lower Quinault sub-basin.

Lakes

- Investigate changes in the delta near the Lake Quinault inlet.

- Continue to investigate the productivity of Lake Quinault.

Biological Processes

- Investigate biological processes and fish community structures within the Quinault River Basin. Examples include measurements to characterize current levels of primary productivity in Lake Quinault and evaluations of existing and potential nutrient sources that could be employed for supplementation.

Data Needs for Salmonid Habitat Assessments in the Queets Basin

This report was limited in its ability to clarify and prioritize impacts because of key data gaps. The following is a list of data needs that have been identified by the TAG. These data would greatly aid in developing effective recovery plans and to monitor the effectiveness of salmon habitat projects. The studies will also help better identify habitat limiting factors for salmonid production in the future. The TAG designated data needs associated with a red diamond as "high priority".

Fish

- The distributions of anadromous and resident fishes throughout the basin should be documented to characterize habitat uses by season and life history stages to support habitat limiting factor analyses and to support identification of production and/or survival bottlenecks.

Access

- A complete inventory of blockages (including lateral blockages to off-channel habitat and debris dams) is needed throughout the Queets Basin outside of the Olympic National Park. Blockages should be prioritized according to the degree of impact to salmonids.

- Inventory and prioritize undersized culverts that could potentially result in excess sediment delivery and/or block fish access.

Floodplain

- Identify impacts to floodplain habitat and function, and prioritize actions to address impacts.

- Investigate whether remote sensing can produce a more accurate map of wetland habitats.

Streambed/Sediment

- Inventory and prioritize undersized culverts and road fills that could potentially result in excess sediment delivery and/or block fish access.

- Develop a new digital elevation model for WRIA 21 with a minimum of 10 meter resolution size to better reflect current conditions (presently, elevations are based on 50 year old data).

- Continue to study the direct impacts of landslides on salmonid production.

Riparian

- Estimate riparian conditions from remote methods combined with ground verification, following State watershed analysis procedures throughout the Queets Basin, prioritizing the Clearwater River and tributaries and the Queets River downstream of the Olympic National Park boundary.

Water Quality

- Conduct a study to better assess water temperature issues in the Clearwater and lower Queets Rivers. The assessment needs to determine likely causes of impact and prioritize restoration actions.

- Using the extensive data set of water temperatures done by tribal, federal and private industry (if available) that has now been collected, investigate the feasibility of developing a nomograph, similar to those currently proposed for central and northeast Washington regions, depicting the regional relationships between elevation, canopy closure and water temperatures. The purpose for development of that tool would be to guide restoration efforts as well as to indicate what range of temperatures may actually be attainable at a particular site.

Biological Processes

- Continue to conduct and monitor the nutrient enrichment program within the Clearwater River.

Data Needs for Salmonid Habitat Assessments in the Kalaloch, Raft, Moclips, Joe, Copalis, and other Small Coastal Watersheds

This report was limited in its ability to clarify and prioritize impacts because of key data gaps. The following is a list of data needs that have been identified by the TAG. These data would greatly aid in developing effective recovery plans and to monitor the effectiveness of salmon habitat projects. The studies will also help better identify habitat limiting factors for salmonid production in the future. The TAG designated data needs associated with a red diamond as "high priority".

Fish Data

- The distributions of anadromous and resident fishes throughout these basins should be documented to characterize habitat uses by season and life history stages to support habitat limiting factor analyses and to support identification of production and/or survival bottlenecks.

Access Conditions

- Inventory, assess, and prioritize blockages to salmonid habitat in these watersheds. Coordinate prioritization between agencies and ownerships.

Floodplain Conditions

- Inventory, assess, and prioritize impacts from roads and land use to floodplain habitat.

- Investigate whether remote sensing can produce a more accurate map of wetland habitats.

Streambed Sediment Conditions

- Inventory roads and culverts that have the potential to, or which do, deliver sediment to streams.

- Develop a new digital elevation model for WRIA 21 with a minimum of 10 meter resolution size to better reflect current conditions (presently, elevations are based on 50 year old data).

Riparian Conditions

- Estimate riparian conditions from remote methods combined with ground verification, following State watershed analysis procedures. Prioritize areas for restoration and preservation.

Water Quality Conditions

- Investigate water quality conditions and causes of water quality exceedances in the independent streams outside of the Queets and Quinault Basins.

Recommendations for Salmonid Habitat Assessments in WRIA 21 Estuaries and Near Shore Habitat

- Studies are needed to delineate habitat characteristics and fish use in the small estuaries within WRIA 21. Areas should be prioritized for restoration or protection.

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